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Experimental Investigation of Surface Water Infiltration in Urban Drainage Channels Using Pervious Concrete

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ABSTRACT

Urban development and the overuse of groundwater resources, along with the reduction of permeable surfaces due to the construction of residential areas and asphalt roads, have greatly reduced valuable water resources. As a result, these resources have lost part of their ability to provide water, causing many problems for citizens. In addition, impermeable surfaces can increase the risk of pollution entering water resources. This study investigates the role of pervious concrete as an economical and environmentally friendly solution for urban flood management and surface water collection. Due to its high porosity and the spaces between its materials, pervious concrete can be a suitable material for constructing urban channels. In this study, after selecting a suitable concrete mix design, a glass channel with a pervious concrete bed was built. The pervious concrete covered only 10% of the total channel bed area. Experiments were carried out at different flow rates, ranging from 4 to 22 liters per minute, and at different slopes of 0, 2, 4, and 6 per thousand. The results showed that the use of pervious concrete helped water infiltrate into the bed by 7% to 15%, depending on the inlet flow rate. The findings also showed that using this type of concrete could delay the time to reach the peak flood flow by up to 10%, while allowing surface water to be collected in a shorter time. Based on the average inlet flow rates, the channel with a slope of 4 per thousand carried a higher flow rate than the channels with the other slopes.

1. Introduction

Urban development and population growth have increased the need for water in many cities. At the same time, the increase in roads, buildings, parking areas, and other hard surfaces has reduced the amount of water that can enter the soil. As a result, more rainwater flows over the ground and enters urban drainage channels. This condition increases surface runoff and the risk of urban flooding. In addition, runoff can carry different pollutants from roads and other urban surfaces into rivers and groundwater resources (Rashidi Mehrabadi and Sadeghian, 2013). Therefore, proper management of urban runoff is an important issue in civil engineering, especially in areas with limited water resources. The amount of surface runoff during rainfall depends on different conditions, such as rainfall intensity, land use, soil properties, ground slope, and the size of the catchment. When natural land is changed into urban areas, the amount of water entering the soil usually decreases, while the amount and speed of surface runoff increase. This change can also reduce the time needed for runoff to reach drainage channels and downstream areas. Consequently, existing urban drainage systems may not have enough capacity to carry the increased flow during heavy rainfall events (Safavi, 2009; Rashidi Mehrabadi and Sadeghian, 2013). For this reason, the design of urban drainage channels should consider both the amount of runoff and the effect of urban development on its flow. Urbanization also affects the natural water cycle in other ways. The reduction of vegetation and the increase in impervious surfaces can reduce water infiltration and groundwater recharge. At the same time, rainwater flowing over roads and roofs can collect oil, dust, tire particles, heavy metals, and other pollutants. These materials may enter drainage systems and finally reach rivers and groundwater resources. Therefore, urban runoff is not only a problem related to flooding, but it can also affect water quality and the environment (Kamali et al., 2011; Maleki and Taghizadeh, 2012). The use of suitable methods to reduce runoff and allow part of the water to enter the ground can help to control these problems. Traditional urban drainage systems mainly aim to collect and transfer rainwater as quickly as possible from urban areas to downstream locations. Although this method can reduce water accumulation in some places, it

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may increase the flow rate in downstream areas and transfer the flooding problem from one location to another. Large drainage channels can also increase construction costs and may not provide enough protection during heavy rainfall. For this reason, better management methods are needed to reduce runoff near its source, increase infiltration, and delay the movement of rainwater through the drainage system (Rashidi Mehrabadi and Sadeghian, 2013). Best Management Practices (BMPs) and Low Impact Development (LID) methods are among the approaches used to improve urban runoff management. These methods include infiltration areas, storage systems, and permeable surfaces that help reduce runoff and support groundwater recharge (Kamali et al., 2011; Raisipour et al., 2014). One of the main methods for reducing surface runoff is to increase the infiltration of rainwater into the ground. Natural soil and vegetation can store and absorb part of rainfall, but these functions are reduced when the land is covered by asphalt and concrete. Increasing the infiltration capacity of urban surfaces can help to reduce the amount of water entering drainage channels and may delay the arrival of peak flow. This is important because a longer time to reach peak flow can provide more time for collecting and managing rainwater. In addition, infiltration can help return part of the collected water to groundwater resources, which is important in dry and semi-dry regions (Mohammadi et al., 2015). Iran is located mainly in a dry and semi-dry region, where water resources are limited and rainfall is relatively low. Population growth, urban expansion, and increased water demand have created serious challenges for water supply and management. In these conditions, the collection and proper use of rainwater can be useful for reducing pressure on existing water resources. Zahedan is an important example of a city facing these problems. It is located in southeastern Iran, where low rainfall and high demand for water have made water management especially important. The local groundwater resources are limited, and rapid urban development and high groundwater extraction have increased the pressure on these resources (Khosravi et al., 2007). Therefore, methods that can reduce urban flooding and help rainwater enter the ground may be useful for this city. Porous concrete is one of the materials that can be used to improve water infiltration in urban areas. Unlike ordinary concrete, porous concrete has a larger number of connected empty spaces between its aggregates. These spaces allow water to pass through the concrete instead of remaining on the surface. For this reason, porous concrete has been used in different civil engineering applications, such as permeable pavements, drainage layers, and systems for collecting and controlling runoff. Its performance depends on several factors, including aggregate size, mix proportions, cement content, water-to-cement ratio, and the amount of empty space in the concrete (Shirgir et al., 2011; Hejazi et al., 2012). A suitable mix design is therefore necessary to provide enough permeability while maintaining acceptable strength. Previous studies have investigated the use of porous concrete for different purposes. Vaziri (2010) studied the use of porous concrete instead of a sand filter below the lining of irrigation channels. The results showed that porous concrete could provide a suitable path for collecting and transferring seepage water, while also reducing construction time and the movement of filter materials. Shirgir et al. (2011) studied the effect of aggregate grading on the physical properties and permeability of porous concrete. Their results showed that changes in aggregate grading affected both concrete strength and permeability. Hejazi et al. (2012) also investigated porous concrete as a surface material for roads and discussed the importance of mix design, compaction, and maintenance for achieving suitable performance. Other studies have examined the use of porous materials in runoff management. Maleki and Taghizadeh (2012) discussed the use of porous asphalt as a method for managing urban surface runoff. Their work explained that permeable surfaces can allow rainwater to enter the ground and reduce the amount of water flowing over roads and pavements. Koopaee and Javaheri Tehrani (2013) studied porous concrete for treating polluted water under emergency conditions. Koopaee et al. (2013) also investigated porous concrete containing zeolite for the treatment and management of urban floodwater. Their findings showed that porous concrete can have potential benefits for reducing some pollutants in runoff, depending on the materials used. These studies indicate that porous concrete may provide both hydraulic and environmental benefits when it is designed and used correctly. The hydraulic performance of permeable surfaces is also affected by slope and flow conditions. Slope can change the speed and depth of water movement and the time available for infiltration. Grahl (2012) studied the hydraulic design of porous concrete highway shoulders, while West et al. (2015) examined surface flow and water spread near porous pavement bicycle lanes. Their studies showed the importance of considering the flow conditions and surface geometry when designing permeable pavement systems. In addition, Sifi et al. (2012) investigated the effect of slope on runoff in soils that are sensitive to surface crust formation. Their work showed that the relationship between slope and runoff can depend on soil properties and the conditions of the experiment. Therefore, the effect of slope should be examined for each drainage system rather than assuming that the same result will occur under all conditions. The use of porous concrete in urban drainage channels may provide another way to improve runoff management. In a conventional channel, most of the water is transferred downstream, while only a small amount may enter the ground through joints or cracks. If part of the channel bed is made of porous concrete, some water may pass through the concrete and enter the underlying soil. This process can reduce the volume of water moving through the channel and may support groundwater recharge. However, the amount of infiltration depends on the flow rate, channel slope, concrete properties, and the area of porous concrete in contact with water. The channel must also provide enough capacity to transfer the remaining flow safely during rainfall events. For this reason, laboratory experiments are needed to evaluate the

performance of porous concrete under different flow conditions. Although several studies have examined porous concrete in pavements, irrigation channels, and drainage systems, its use as a partial bed material in urban surface-water channels needs further investigation. In particular, the effect of different flow rates and channel slopes on infiltration and water movement should be studied. It is also important to determine whether using porous concrete can delay the arrival of peak flow while maintaining the ability of the channel to transfer surface water. These issues are important for cities where water resources are limited and urban flooding is a repeated problem. The main aim of this study is to investigate the use of porous concrete in an urban channel for surface-water collection and runoff management. For this purpose, a laboratory channel was built with a glass body and a porous concrete bed. The porous concrete covered only 10% of the total channel bed area. Experiments were carried out at different flow rates, from 4 to 22 L/min, and at channel slopes of 0, 2, 4, and 6 per thousand. The results were used to evaluate the effect of flow rate and slope on water infiltration and channel flow. The study also examined the possibility of delaying peak flow by using porous concrete. The findings can help to explain the potential use of porous concrete in urban drainage channels, especially in dry and semi-dry regions such as Zahedan.

2. Materials and Methods

2.1. Materials and Preparation of Pervious Concrete

In this study, pervious concrete was used as the permeable bed of an open channel to investigate water infiltration from surface flow. The main purpose of using this concrete was to provide connected voids through which water could pass from the channel into the underlying soil. The concrete mixture consisted of coarse aggregates, Portland cement, and water. Fine aggregates were limited to maintain the porous structure and provide suitable water infiltration capacity. Type II Portland cement produced by Khash cement factory was used in this study. No chemical admixtures were used in the concrete mixtures. The selection of aggregate size and grading was an important part of the preparation process because aggregate characteristics affect both the pore structure and the mechanical strength of pervious concrete. A suitable aggregate distribution was required to provide sufficient connections between aggregate particles while maintaining the voids needed for water movement. The materials required for each mixture were weighed before mixing (Figure 1). This step was carried out to control the mixture proportions and prepare the concrete specimens under defined conditions. Aggregate grading was also examined before concrete production to check the size distribution of the aggregates used in the mixtures.



Fig 1. Weighing of materials for the preparation of pervious concrete mixtures.

The prepared aggregates were then mixed with cement and water. The fresh concrete was placed on a vibrating table to prepare the specimens. In pervious concrete, compaction should be controlled because insufficient compaction may reduce the contact between aggregates, whereas excessive compaction may reduce the connected void space. Therefore, the preparation process was conducted with attention to both the structural integrity and the permeability of the concrete (Figure2).



Fig 2. Pervious concrete placed on the vibrating table during specimen preparation.

After preparation, the water permeability of the concrete was examined to confirm that the specimen provided pathways for water movement. This stage was important because the concrete was intended to be installed at the bottom of the experimental channel and used as the infiltration surface. The specimen therefore needed to provide water passage while maintaining sufficient

integrity for installation and experimental operation (Figure3).



Fig 3. Water permeability of the prepared pervious concrete specimen.

2.2. Experimental Flume Design and Construction

A laboratory open-channel flume was constructed to investigate infiltration from surface water flow through the pervious concrete bed. The dimensions of the flume were selected based on measurements of common urban drainage channels in Zahedan, Iran. The channel was 4 m long, 0.40 m wide, and 0.25 m high. These dimensions were selected to provide a physical model of an urban drainage channel and allow the flow and infiltration processes to be investigated under controlled experimental conditions. The channel walls were made of 6-mm-thick glass. The transparent walls allowed direct observation of the water surface, flow depth, and general flow conditions during the experiments. The flume was installed on a metal frame approximately 1 m above the ground to provide access to the underside of the channel and facilitate observation of the infiltration section. The channel was constructed and installed to maintain stable geometric conditions during the experiments. A firm support was provided to reduce the possibility of movement or settlement that could change the longitudinal slope and affect the flow measurements. The experimental model was installed outdoors (Figure4).



Fig 4. Construction of the laboratory flume used for the infiltration experiments.

The water supply system consisted of a storage tank with a volume of 6 m³ and a pump with a nominal capacity of 100 L/min. The tank provided the water required for the experiments, while the pump transferred water to the channel. This arrangement allowed water to be supplied to the flume during the experimental runs (Figure 5). At the upstream and downstream ends of the channel, 90° triangular weirs were installed to measure the inlet and outlet flow rates. These measuring structures were used to determine the flow entering and leaving the flume. The difference between these flow rates provided the main basis for estimating water infiltration through the permeable bed. The weirs were intended to operate under suitable free-flow conditions during measurements.



Fig 5. Laboratory flume equipped with triangular weirs at the inlet and outlet.

The main geometric and hydraulic characteristics of the constructed model are presented in Table 1.

Table 1. Main characteristics of the experimental flume

Parameter	Value
Channel shape	Rectangular
Channel width	0.40 m
Channel depth	0.25 m
Glass thickness	6 mm
Support height	Approximately 1 m
Porous concrete dimensions	0.40 × 0.40 × 0.075 m
Soil container depth	0.15 m
Number of holes in the container	100
Diameter of each hole	10 mm
Storage tank volume	6 m^3
Nominal pump capacity	100 L/min
Inlet and outlet weirs	Triangular, 90°

2.3. Infiltration Experimental Setup and Measurement Procedure

The main infiltration section consisted of a pervious concrete specimen installed at the bottom of the channel and a soil container positioned beneath it. The concrete specimen measured 40×40×7.5 cm and provided the permeable surface in contact with the flowing water. Water moving along the channel could pass through the connected pores of the concrete and enter the underlying soil.

A soil container was installed beneath the concrete specimen. The container had a plan area corresponding to the concrete specimen and a thickness of 15 cm. Its bottom contained 100 holes, each with a diameter of 10 mm. This arrangement provided a space for the soil beneath the concrete and allowed water to pass through the experimental section. The dimensions and arrangement of this section were selected to investigate infiltration through the concrete and the underlying soil within the laboratory model.



Fig 6. Pervious concrete specimen installed at the bottom of the experimental channel.



Fig 7. Soil container installed beneath the pervious concrete specimen.

Before each experimental run, the flume and its water supply system were prepared for operation. Water was supplied from the storage tank by the pump and introduced into the channel. The flow passed along the flume and over the previous concrete section, where part of the water could infiltrate through the concrete and enter the soil below. The inlet and outlet flow rates were measured using the triangular weirs installed at the two ends of the channel (Figures 6, 7).

The infiltration discharge was estimated using the water balance between the inlet and outlet flow rates. Assuming

that changes in water storage within the channel were negligible during the measurement period and that other losses, such as evaporation, were insignificant, the infiltration discharge was calculated as follows:

$$Qinf=Qin-Qout \quad (1)$$

where Qinf is the infiltration discharge, Qin is the inlet discharge, and Qout is the outlet discharge. All discharge values were expressed in consistent units. This relationship was the main calculation used to estimate the amount of water infiltrating through the pervious concrete section. The longitudinal slope of the flume and the inlet discharge were considered important experimental variables.

Changes in slope can affect flow velocity, water depth, and the contact conditions between water and the permeable bed. Similarly, changes in inlet discharge can modify the flow conditions and the difference between inlet and outlet discharges. The experimental arrangement was therefore designed to investigate infiltration under different flow conditions and channel slopes.

The hydraulic condition of the flow can also be described using the Froude number, which relates the mean flow velocity to the characteristic velocity of gravity waves. It is expressed as:

$$Fr=V/gD \quad (2)$$

where Fr is the Froude number, V is the mean flow velocity, g is gravitational acceleration, and D is the hydraulic depth. The hydraulic depth is calculated as D=A/T, where A is the cross-sectional flow area and T is the free-surface width. This parameter can be used to describe the flow regime during the experiments.

For each experimental run, the measured flow rates and the corresponding test conditions were recorded. The collected data were organized for subsequent statistical analysis using SPSS. The software was used to manage and analyze the experimental data and examine the relationships between the measured variables. The experimental results and their interpretation are presented separately in the following section of the article.

3. Results and discussion

3.1. Porous Concrete Mix Design and Selection

Three porous concrete mixtures were prepared and tested to identify a suitable mix for a drainage channel. The main selection criteria were porosity, water permeability, and sufficient compressive strength for the intended application. As shown in Table 1, Mix 1 had a void ratio of 31% and a compressive strength of 42 kg/cm². Mixes 2 and 3 had higher void ratios of 36%, while their compressive strengths were 65 and 110 kg/cm², respectively (Table2).

Table 2. Comparison of porous concrete mix designs

Mix design	Void ratio (%)	Compressive strength (kg/cm²)
Mix 1	31	42
Mix 2	36	65
Mix 3	36	110

The results show that Mix 2 provided a suitable balance between porosity and compressive strength. Although Mix 3 achieved a higher compressive strength, its void ratio was the same as that of Mix 2. Since water infiltration was the main objective of this study, Mix 2 was selected for the construction of the experimental channel. This mixture provided sufficient strength for the laboratory application while maintaining a high void ratio (Figure8).

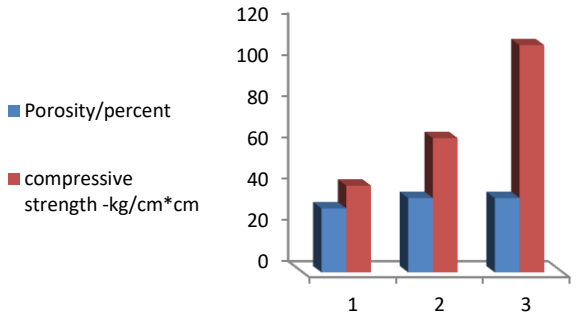


Fig 8. Comparison of the void ratio and compressive strength of the three porous concrete mixtures

3.2. Soil Properties and Permeability

Soil samples collected from Zahedan were classified mainly as silty sand and well-graded sand, with some samples containing gravel or additional fine particles. These soil types can provide suitable conditions for infiltration, although the actual infiltration rate depends on soil density, moisture content, particle-size distribution, and the degree of saturation. The laboratory constant-head permeability test gave a hydraulic conductivity of

approximately 1.502×10^{-3} cm/s for the selected soil sample. This value indicates that water can pass through the soil, but the rate of infiltration may still limit the overall performance of the porous channel. Therefore, the performance of the system depends on both the permeability of the concrete and the hydraulic properties of the underlying soil.

3.3. Experimental Performance of the Porous Channel

A total of 29 laboratory experiments were conducted using different inlet flow rates and channel slopes. During each experiment, the inlet discharge, outlet discharge, infiltrated discharge, water depth, and filling time were recorded. The results showed that the porous concrete channel increased the time required to fill the receiving tank compared with the conventional channel without porous concrete. The comparison of filling times showed mean values of 1,351 seconds with porous concrete and 1,708.5 seconds without porous concrete. The independent-samples t-test indicated a statistically significant difference between the two conditions (p=0.044). The results therefore suggest that the porous channel can delay water transfer under the tested laboratory conditions (Figure9).

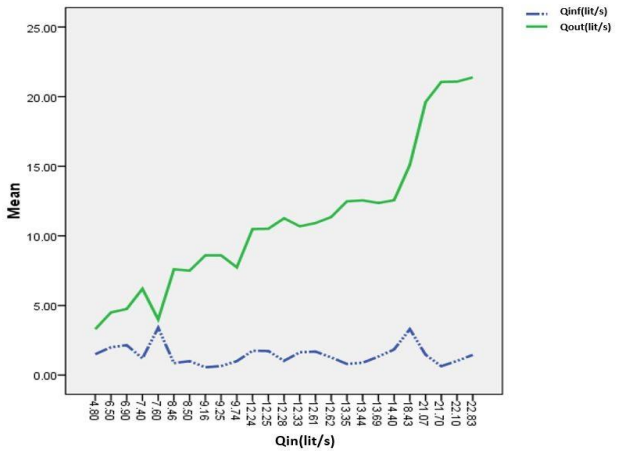


Fig 9. Comparison of the receiving-tank filling time with and without porous concrete.

The percentage increase in filling time varied with the inlet discharge. For inlet flow rates of 0–10 L/min, the reported average increase was 17%. The corresponding increases were 7% for flow rates of 10-15 L/min and 9% for flow rates of 15-20 L/min. These findings suggest that the effect of porous concrete was more noticeable at lower inlet flow rates. This delay may be useful for urban stormwater management because infiltration can temporarily reduce the volume of water transported through a drainage system. However, the increase in laboratory filling time should not be interpreted directly as an equivalent increase in the time to peak discharge in a real urban catchment. Further field studies are required to assess this effect under natural rainfall conditions.

3.4. Effect of Channel Slope on Infiltration

The mean inlet and infiltrated discharges were compared at four channel slopes: 0, 2, 4, and 6%. The mean infiltration rates were 1.22, 1.39, 1.82, and 1.20 L/min, respectively.

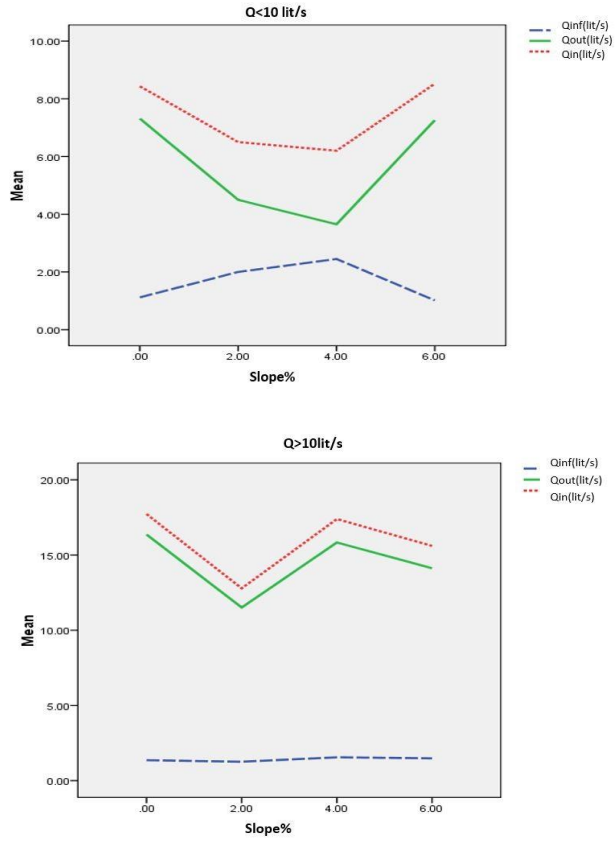


Fig 10. Mean infiltration discharge at different channel slopes

The highest mean infiltration rate was observed at a slope of 4%. At this slope, the mean infiltration discharge reached 1.82 L/min, compared with 1.22 L/min at zero slope and 1.20 L/min at 6%. These results indicate that the relationship between channel slope and infiltration was not linear. Increasing the slope from 0 to 4% was associated with higher infiltration, whereas a further increase to 6% reduced the mean infiltration rate (Figure 10).

A possible explanation is that channel slope changes the water velocity and the time available for contact between water and the porous surface. However, these mechanisms were not directly measured in this study. Therefore, a slope of 4% can be considered the most suitable slope among the tested conditions, rather than a universally optimal value. The Pearson correlation analysis also showed that the overall relationship between slope and infiltration discharge was not statistically significant (r=0.012, p=0.952). This result does not necessarily contradict the observed differences in mean infiltration at individual slopes, because the correlation analysis evaluates the overall linear relationship across the available observations. The limited sample size and variation in inlet discharge may also affect the results.

3.5. Statistical Analysis of Flow Parameters

Pearson correlation analysis was used to examine the relationships between infiltration discharge, outlet discharge, inlet discharge, water depth, slope, and filling time. The results showed a strong positive correlation between inlet and outlet discharge (r=0.803, p=0.001). This indicates that higher inlet flow rates were generally associated with higher outlet flow rates. Outlet discharge was also positively correlated with water depth (r=0.763, p=0.001). In contrast, the percentage increase in filling time had a negative correlation with outlet discharge (r=−0.663, p=0.001). These findings suggest that the hydraulic response of the channel was strongly related to the amount of water entering the system and the water level within the channel.

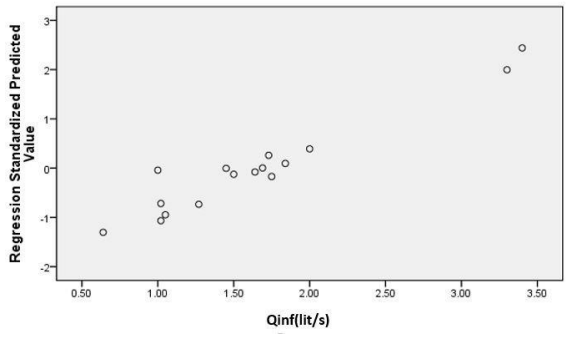


Fig 11. Relationships between inlet discharge, outlet discharge, and infiltrated discharge

No statistically significant correlation was found between inlet discharge and infiltration discharge (r=0.280, p=0.157). Similarly, infiltration discharge was not significantly correlated with water depth, outlet discharge, slope, or filling time at the 5% significance level. These results indicate that infiltration discharge did not follow a clear linear relationship with the individual hydraulic parameters examined in this study (Figure 11).

The lack of significant correlations does not mean that these parameters have no physical influence on infiltration. Instead, it suggests that their individual linear relationships could not be established statistically from the available experimental data. Interactions between flow rate, slope, water depth, and the properties of the porous concrete may require further investigation.

3.6. Regression Models and Prediction Accuracy

Multiple regression analysis was performed to estimate infiltration and outlet discharge using the measured hydraulic variables. For infiltration discharge, the three reported models had coefficients of determination (R2) of 0.933, 0.932, and 0.930. All three models were statistically significant according to the reported F-tests (p=0.001). The results indicate that the selected variables explained a large proportion of the observed variation in infiltration discharge within the experimental dataset.

In the third infiltration model, water depth, outlet discharge, and inlet discharge were included as predictors. The estimated equation was:

$$Qinf=-0.326h-0.907Qout+0.960Qin+5.154$$

where Qinf is infiltration discharge, h is water depth, Qout is outlet discharge, and Qin is inlet discharge. The coefficients indicate negative associations for water depth and outlet discharge and a positive association for inlet discharge when the other variables are held constant.

For outlet discharge, the three regression models had reported R2 values of 0.978, 0.985, and 0.990. The third model included water depth, infiltration discharge, and inlet discharge. Its estimated equation was:

$$Qout=-0.297h-1.007Qinf+1.053Qin+4.490$$

The high R2 values indicate a strong fit to the experimental data. However, the regression equations should be used with caution because inlet, outlet, and infiltrated discharge are physically related through the water balance. Consequently, a high coefficient of determination does not

necessarily demonstrate that the models can accurately predict discharge under different conditions.

The reported prediction errors also indicate considerable variation between measured and estimated infiltration values. The third infiltration model had the lowest reported mean percentage error (44.92%), although some individual errors were substantially higher. Therefore, additional validation using independent experimental data is necessary before these equations can be used for design purposes.

3.7. Overall Findings and Engineering Implications

The experimental results demonstrate that porous concrete can be used as a permeable surface in a laboratory drainage channel. The selected mixture had a void ratio of 36% and a compressive strength of 65 kg/cm². The experiments also showed a statistically significant increase in receiving-tank filling time when porous concrete was used.

Among the tested channel slopes, 4% produced the highest mean infiltration discharge. The statistical analysis further showed that inlet discharge was strongly associated with outlet discharge, whereas no significant linear relationship was identified between inlet discharge and infiltration discharge.

Overall, the findings support the potential use of porous concrete to improve infiltration and delay water transfer in urban drainage systems. Nevertheless, the results are based on laboratory-scale experiments, and the effects of long-term clogging, rainfall variability, soil saturation, and field conditions were not evaluated. Further laboratory and field investigations are therefore recommended to confirm the durability and practical performance of porous concrete drainage channels.

4. Conclusion

This study investigated the use of pervious concrete in urban drainage channels to improve water infiltration and reduce surface runoff. A laboratory channel with a pervious concrete bed was constructed, and 29 experiments were conducted at different inlet flow rates and channel slopes. Based on the experimental results and statistical analyses, the following conclusions can be drawn.

1. Among the three concrete mixtures, Mix 2 was selected for the experimental channel. This mixture had a void ratio of 36% and a compressive strength of 65 kg/cm², providing a suitable balance between porosity and strength for the intended application.

2. The experimental results showed that pervious concrete increased the time required to fill the receiving tank compared with a conventional channel without pervious concrete. The average filling time increased from approximately 1,709 to 1,351 seconds when the concrete was removed, indicating a significant difference between the two conditions. The statistical analysis confirmed that this difference was significant at the 5% level ($p=0.044$). The reported increase in filling time varied with the inlet flow rate, with a greater effect observed at lower flow rates.

3. The infiltration performance depended on the hydraulic conditions of the channel. Among the tested slopes of 0, 2, 4, and 6%, the slope of 4% produced the highest mean infiltration discharge, approximately 1.82 L/min. At a slope of 6%, the mean infiltration discharge decreased to 1.20 L/min. Therefore, a slope of 4% was identified as the most suitable condition among those tested in this study.

4. The statistical analysis showed a strong positive relationship between inlet and outlet discharge ($r=0.803$, $p=0.001$). A significant positive relationship was also observed between water depth and outlet discharge ($r=0.763$, $p=0.001$). However, no statistically significant linear relationship was found between inlet discharge and infiltration discharge ($p=0.157$). These findings indicate that the infiltration process cannot be explained by inlet discharge alone and may also depend on the combined effects of channel geometry, flow conditions, and the properties of the underlying soil.

5. The multiple regression models showed high coefficients of determination for both infiltration and outlet discharge. However, the relatively high prediction errors for some experimental observations indicate that further calibration and validation are needed before these models can be applied to full-scale drainage systems.

Overall, the findings demonstrate that pervious concrete has the potential to improve infiltration and delay water transfer in urban drainage channels. This approach may help reduce surface runoff and support more sustainable

stormwater management. However, the results are based on laboratory-scale experiments, and the long-term effects of clogging, soil saturation, and changing rainfall conditions were not investigated. Further field studies are recommended to evaluate the performance and durability of pervious concrete channels under real urban conditions.

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