INFILTRATION CAPACITY OF INTERLOCKING CONCRETE PAVEMENT

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ABSTRACT: This paper has for objective to evaluate the infiltration capacity of the interlocking concrete pavement, used two lysimeters (construction in reduction scale), being one with grassy and another one with the interlocking concrete pavement. These lysimeters had been installed in opened area, in order to be in contact with the local conditions, of precipitation. Each lysimeter possess two reservoirs, one in superior, for the collection the superficial runoff, and the inferior for the infiltration water. One lysimeter was elaborated with proper the local ground (Red Nitosol) and the grass. The other Lysimeter was constructed with the different layers, having been the gravels, cover of a permeable geotextile, aggregate bedding course and the interlocking concrete pavement, with joint width 6 or 7 mm. The experiments showed that the performances of two lysimeters were similar.

Key Words: interlocking concrete pavement, lysimeter and Permeable Pavement.

1. INTRODUCTION

The waterproofing of ground in the great cities has generated the increase of the superficial runoff and contributed for urban floods. To solve this problem some structural and not structural alternatives exist, as example, the use of permeable pavement. The permeable pavements assist in the infiltration of the pluvial water in the urban soil. Of this principle, the interlock concrete pavement are considered permeable pavement, due to infiltration through the joints, and this pavement has been installed in the majority of the Brazilian's cities, as solution of reduction of superficial runoff (figure 1).

Figure 1: examples of cities in Brazil, using a interlock concrete pavement.

Named "the ecological sidewalk", this pavement are being implanted and substituting the grass, in public places or squares. However, still it lacks research of evaluation of infiltration capacity of the interlocking concrete pavement, therefore these will only be considered permeable with the installation the hydraulics structures, as layers with gravels, permeable geotextile and aggregate bedding course (not sand). Another factor that if must consider is the useful life of this pavement, by the process of compacting and the clogging,due the local use, as traffic of vehicles or person, and more, the sediment deposit by diffuse pollution.

Permeable pavements with reservoir structure of concrete paving-stones offer the possibility for a decentralized, sustainable stormwater management and source control in urban areas. Especially, runoff from streets and parking areas with low traffic densities can be infiltrated to support groundwater recharge and to reduce hydraulic stress in sewer systems, receiving waters and wastewater treatment plants. (Dierkes et al.; 2002).

According Marchioni and Silva (2011), the sediment accumulating in the permeable pavement tend to decrease the capacity of infiltration with time. It is considered that in 10 years the permeable pavement has a reduction of 90% of this capacity. That time which sediment buildup occurs depends on the volume of traffic (cars or people) and the existence of sources of sediment near the floor, as gardens and areas prone to transport those solids.

The permeable pavements are usually made of concrete or conventional asphalt, of which the finer particles are, removed (CANHOLI, 2005). In addition to these traditional pavements, there are constructed of grass grid paver (Tucci, Porto and Barros, 1995).

To maintain the life cycle of permeable pavements is necessary the maintenance, that must be performed between once or twice a year, depending on local traffic or even sources of sediment pollution (difuse pollution). The sediments that generate clogging of the surface can be removed by sweeping, which according Marchioni and Silva (2011) and Smith (2006), by a process of suction (no water spray) or in cases of vegetation in the joints, is indicated manually removed, avoiding the use of herbicides which may pollute the environment.

2. PROBLEM IDENTIFICATION

Population growth in cities has led different environmental consequences, such as lack of housing, basic sanitation problems and urban flooding. Even with the stormwater drainage system to find almost all Brazilian cities, it was not considered, in projects constructed in the early twentieth century in Brazil, excessive soil sealing and disposal of solid waste by the population.

Given these factors, the current trend of the master plans of urban storm drainage is to seek new technologies that aim to increase the infiltration and runoff retardation, with the use of compensatory techniques (pavement permeable, rainwater harvesting, green roof and others).

In the region of study, it was observed that, due to local soil, Red Nitosol (clayey soil), presents naturally difficulty in infiltration of water (figure 2), occurring higher runoff, differentiating the permeable pavement, but this floor, even though good infiltration is not considered in Brazil, as an area of infiltration in the lot, but only the soil and the grasses.

Figure 2: water puddle on the Red Nitosol in rainfall of approximately 25 mm.

The main objective of the study presented is to evaluate the infiltration capacity of the interlocking concrete pavement, with two lysimeters (constructed in reduction scale), being one, local soil with grass and another one with the interlocking concrete pavement (paver). To determine the infiltration capacity, it was decided to calculate the coefficient of runoff (C).

3. EXPERIMENTAL METODOLOGY

The research made use of lysimeters, which according to Faria et. Al (2006) apud Paes Junior, Bernardes (2012) consists of tanks or reservoirs containing soils of the area of interest used to study the hydric balance. With this device were determined to used two lysimeters, being built with Red Nitosol soil and grass (scientific name Zoysia japonica, named in Brazil as Esmeralda), and another, with a permeable pavement structure.

The lysimeters exhibit the following internal measurements: 56 cm (depth) and 35 cm (width), with the use of transparent polyethylene containers. Prior to completing the device, was mounted, a drainage layer, for lysimeter with soil and grasses, composed of gravel and geotextile, and installed PVC connection (needled valves) of 10 mm diameter.

The same connection was installed in the upper part of the experiment, to collect the runoff. Each connection was attached a tubing (hose) to direct the flow into the reservoirs, 2 or 5 liters (each). For the lysimeter soil was filled with local soil, clayey characteristic (Red Nitosol), located in State of Paraná, in Brazil. In lysimeter with interlocking concrete pavement (pavers), first was filled with gravel, previously washed, and the another geotêxtil layer. For finally, placed over with stones dust layer, the fitting of interlocking concrete pavement and joints with sand (figure 3).

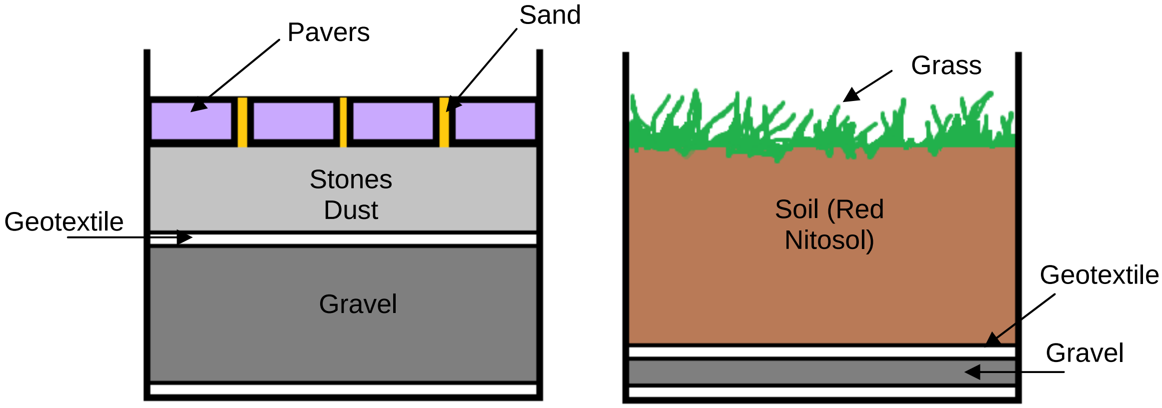

Figure 3: Schematic profile of lysimeters.

Lysimeters were characterized as a closed system, not allowing runoff losses, because it was stipulated a small height of around 10 cm in both lysimeters, for the volume generated in runoff. Lysimeters were installed (figure 4), in the external environment, to have contact with precipitation, with the slope of only 5%, so as to facilitate runoff. For precipitation data, was used the pluviometer digital, installed at the same location.

Figure 4: the lysimeters installed in environment.

4. RESULTS

The rational method is a simple technique for estimating a peak discharge from a small watershed, of less than 5 km^2. The formula is

$$Q = 0.278 \times C \times I \times A \quad (1)$$

where Q is a peak discharge (m^3/s), C is runoff coefficient (dimensionless), I is average rainfall intensity (mm/h) and A is the drainage area (Km^2).

The rational method runoff coefficient (C) is the portion of total precipitation that becomes runoff. The higher its value is the largest formation of runoff and the degree of soil sealing, and their values are in the ranges of 0 to 1.

To estimate potential volumes of rain water leaked in each area, it was taken on the grounds that 1 mm of precipitation corresponds to one liter of water per m^2 area (1 mm = 1 litro.m^2). The determination of the rational method of runoff coefficient (C) is calculated by the ratio of runoff volume (VR) and the precipitate volume (PV), whose values range from 0 to 1.

The values obtained during the survey data collection from September 2013 to January 2014, had, in most cases, with runoff from lysimeters with grasses, null, differentiating the lysimeters with permeable pavements. The results obtained are presented in table 1.

Table 1: results and values of the coefficient C

Precipitation (mm)	*Precipitation Volume (m^3)*	*Volume Paver (m^3)*	*Volume Grass (m^3)*	*Cpaver*	*Cgrass*
75	0,0147	0	0	0	0
39	0,007644	0,0003	0	0,0392	0
49	0,009604	0,00165	0	0,1718	0
12	0,002352	0	0	0	0
13	0,002548	0	0	0	0
91	0,017836	0,0016	0,00015	0,0897	0,0084
35	0,00686	0,00145	0	0,2114	0
21	0,004116	0,00165	0	0,4009	0

Various collected data were discarded because they had errors of collection on site, as well as the difficulty occasioned in periods vacation, and also on weekends, the place where the place was closed (University). The values of coefficient C illustrated that although clay soil, showed no runoff, differentiating the permeable pavement.

It is observed in Table 1, the maximum value of the coefficient C of 0.4009 (on the interlocking concrete pavement), occurred due to the large accumulation of rain over three consecutive days, around 124 mm in order to generate a high surface runoff due to saturation of lysimeter, however, this factor was not representative for the lysimeter soil, with C equal to 0.

In conclusion the results show that lysimeters haved a low runoff coefficient, in different precipitation, with values in 0 to 0,4 for interlocking concrete pavement and values in 0 to 0,0084 for Red Nitosol soil. While a high value of 0.4 in the coefficient C, which represents 60% of the precipitation was infiltrated and held in the reservoir with interlocking concrete pavement.

5. CONCLUSION

The interlocking concrete pavement for use infiltration rainwater are established as a sustainable method for the cities, with various system for different applications, in sidewalks or public places, squares and mall parking lots.

The results are preliminary values of the survey, which should take place for another two years, with more accurate values. It was observed that despite the clay soil of the region, union with grasses, resulted in great part of the runoff retained in tank, and together also the low slope in the assembly of the experiment. The paver also showed good results, that as the amount of rainfall received low formation of runoff if comparison with capacity of infiltration of asphalt pavement.

But other factors must be observed when replacing the grasses by the interlocking concrete pavement, in public places, as the factor of local temperature (temperature rise) and also the luminosity factor that differentiates an area with grasses. Another important factor is the maintenance of permeable pavements in order to prevent blocking, over time, reducing their infiltration capacity.

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