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MDPI

INTERVENTION TIME OF POROUS ASPHALT MIXTURE EVALUATION TO PRE-VENT CLOGGING

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INTRODUCTION

The growing urbanization process of the cities led to an increase in impermeable areas, generating changes in the natural characteristics of watersheds.

An alternative for integrated rainwater management is using porous pavements and surfaces.

The porous asphalt mixtures, are produced with small or no fines to form an open-graded structure and allow water to flow through it. The open gradation results in higher voids content, 18% - 25%.

Due to the interconnected porosity, the water flows out of the pavement during rainfall, avoiding accumulating on the surface. The road safety improvements include more skid resistance and hydroplaning reduction.

INTRODUCTION

Due to clogging, functionality is affected, and the porous pavement cannot propitiate drainage. The rate of clogging depends on factors such as pavement surface, voids content, traffic load, pavement slope, maintenance measures adopted, and environmental and local con-ditions.

In order to contribute to advancing the use of porous mixtures as a pavement surface layer, the primary motivation of this study was to evaluate the clogging by simple permeability tests.

Permeability reduction enabled establishing the needed intervention time to restore porous mixture permeable characteristics. **This study aims to evaluate the maximum time for an intervention of a porous mixture to recover its permeable properties before clogging.**

METHODOLOGY

The porous asphalt mixtures were produced with asphalt rubber fabricated at the Brazilian refinery (terminal blend) with 15% incorporated rubber. Aggregates of granitic origin from southern Brazil were used.

The mixture design was performed according to the ASTM D 7064 standard in the CGS (660 kPa, angle 1.25º, 50 gyrations) and resulted in an asphalt content of 5.0% and void volume of 24.2%.

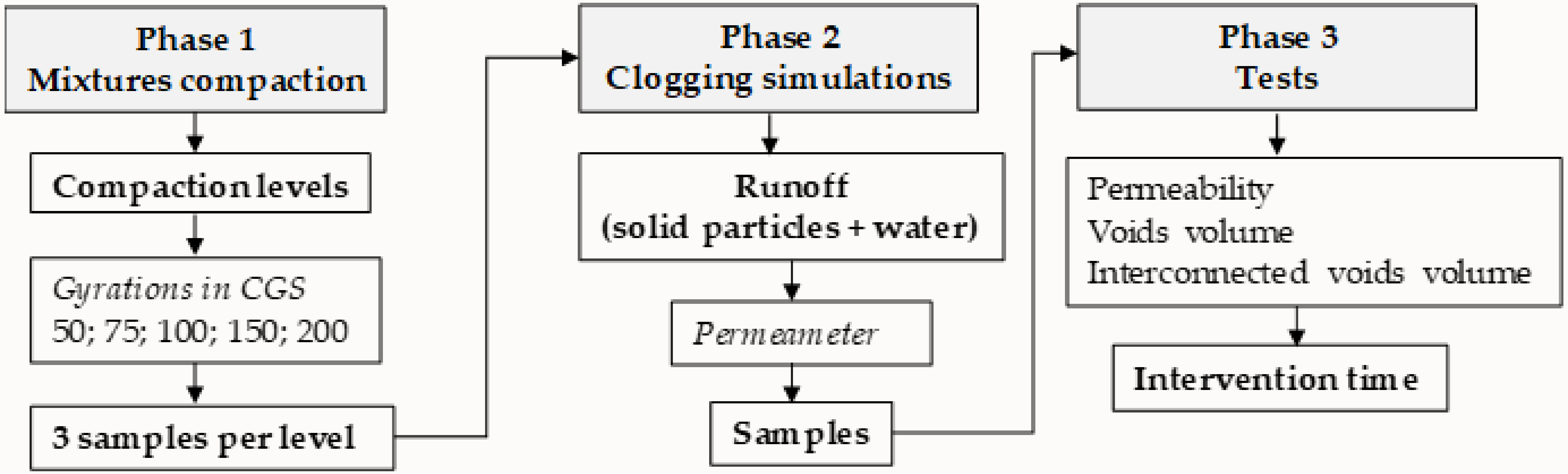
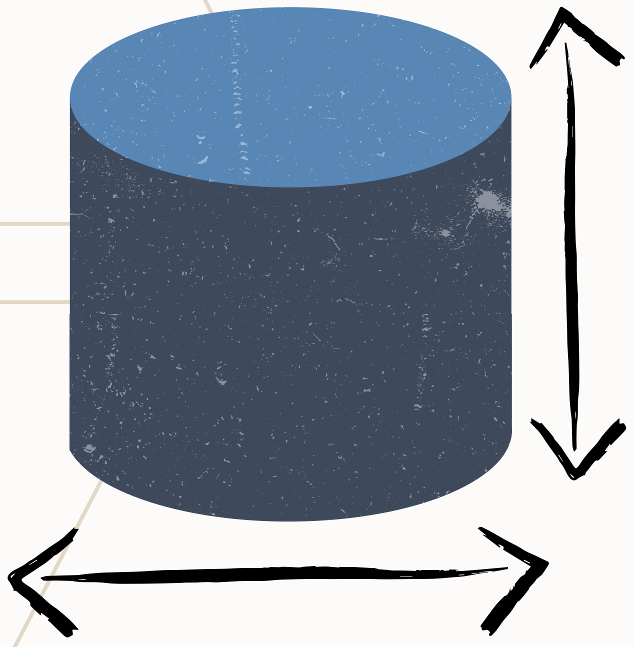


Figure 2. Experimental procedure.

METHODOLOGY

Phase 1

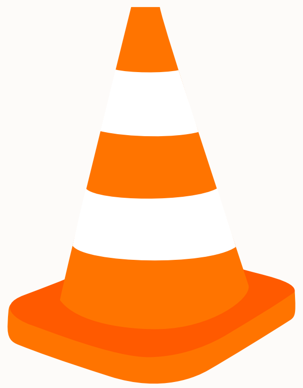


Gyrations

50 - reference
75
100
150
200

3 samples

Phase 2



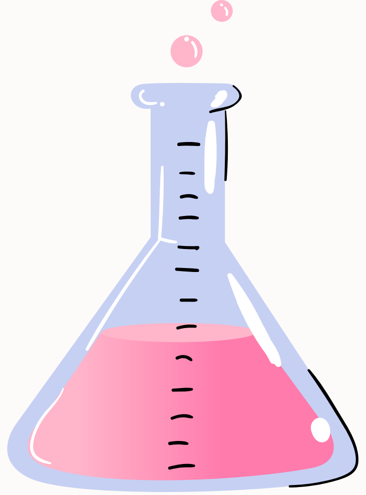
The solid material was selected by sieving, and the fraction retained on sieve No. 100 (0.149 mm) was used.

In the runoff solution to promote the sample clogging, 3.53 grammes of the solid material was added in one water litre.

The initial permeability coefficient (ki) was determined using water, and after five simulations with runoff solution, the final permeability coefficient (kf) was measured.

METHODOLOGY

Phase 3



The runoff solution was introduced into the reservoir, and the samples were submitted to simulation cycles in a constant head permeameter developed by the authors in this study.

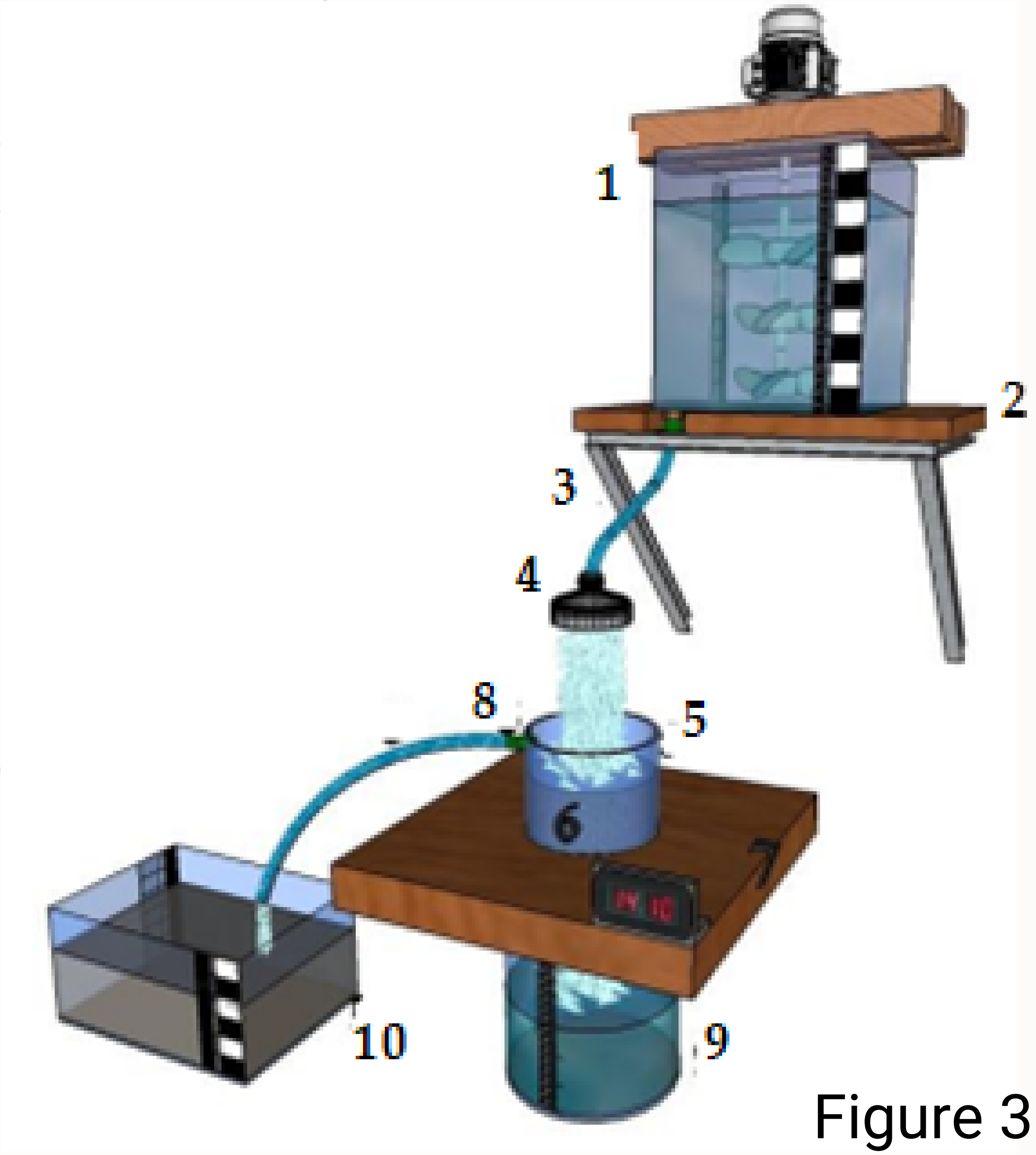
The initial permeability coefficient (ki) was determined using water, and after five simulations with runoff solution, the final permeability coefficient (kf) was measured.

For each sample, the voids volume and the interconnected voids volume were evaluated before and after the simulations.

It was used as a criterion; that means the sample was considered clogged when the interconnected voids volume reached 12%.

METHODOLOGY

Phase 3



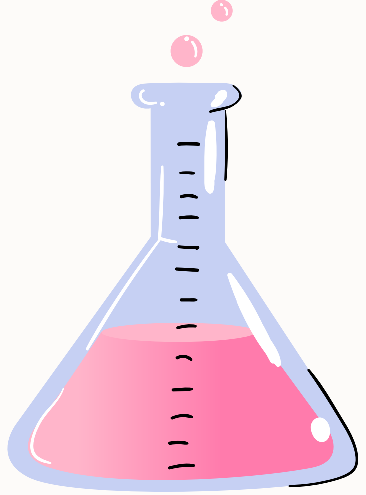
Legend

1. Reservoir (volume 5 litres)
2. Reservoir support elevated 50 cm from the sample
3. Hose (diameter of 10 mm)
4. Plastic shower for water flow control
5. Plastic mould in which the sample is inserted
6. Sample with lateral waterproofed by silicone
7. Support to fixed the sample
8. Spillway (3/8” gauge) to keep the water level above the sample
9. Water collector from the spillway

Figure 3. Constant-head permeameter developed in the study.

METHODOLOGY

Phase 3



For each sample group, the permeability coefficient reduction (kr)was calculated as a function of the mean values distribution and the uncertainty range.

$$\mathbf{kr} = \mathbf{a} \times \mathbf{e}^{-\mathbf{bN}}$$

kr is the permeability coefficient reduction (mm/s);

a and b are regression coefficients;

N is the number of simulations;

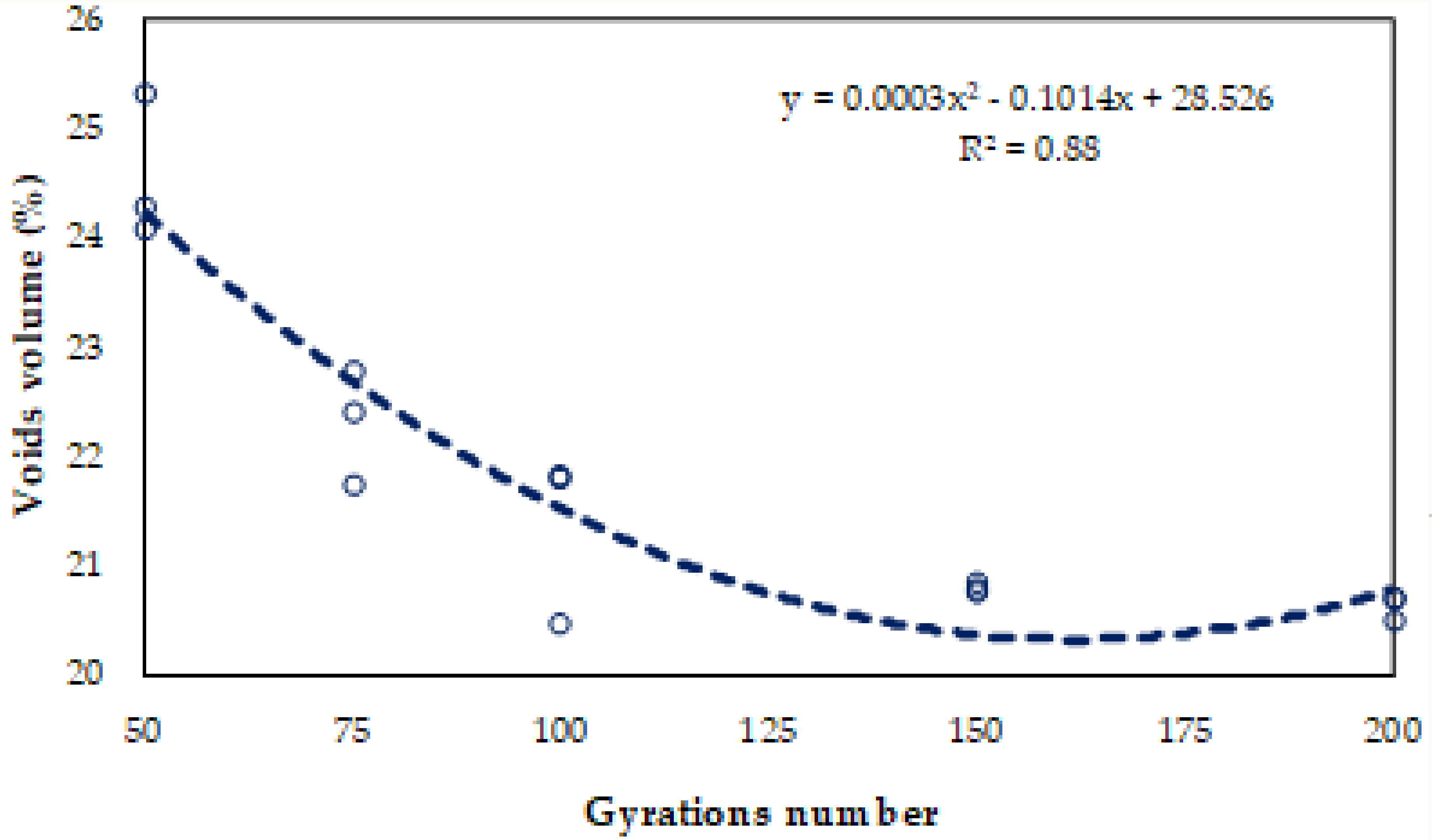
The maximum intervention time in months was established from the number of simu-lations to reach the criteria, considering the annual precipitation average of Florianópolis (1,570 mm).

In this way, for this precipitation, each simulation cycle represents 261.67 mm, and one cycle corresponds to two months.

RESULTS AND DISCUSSION

Influence of compaction effort in the voids reduction

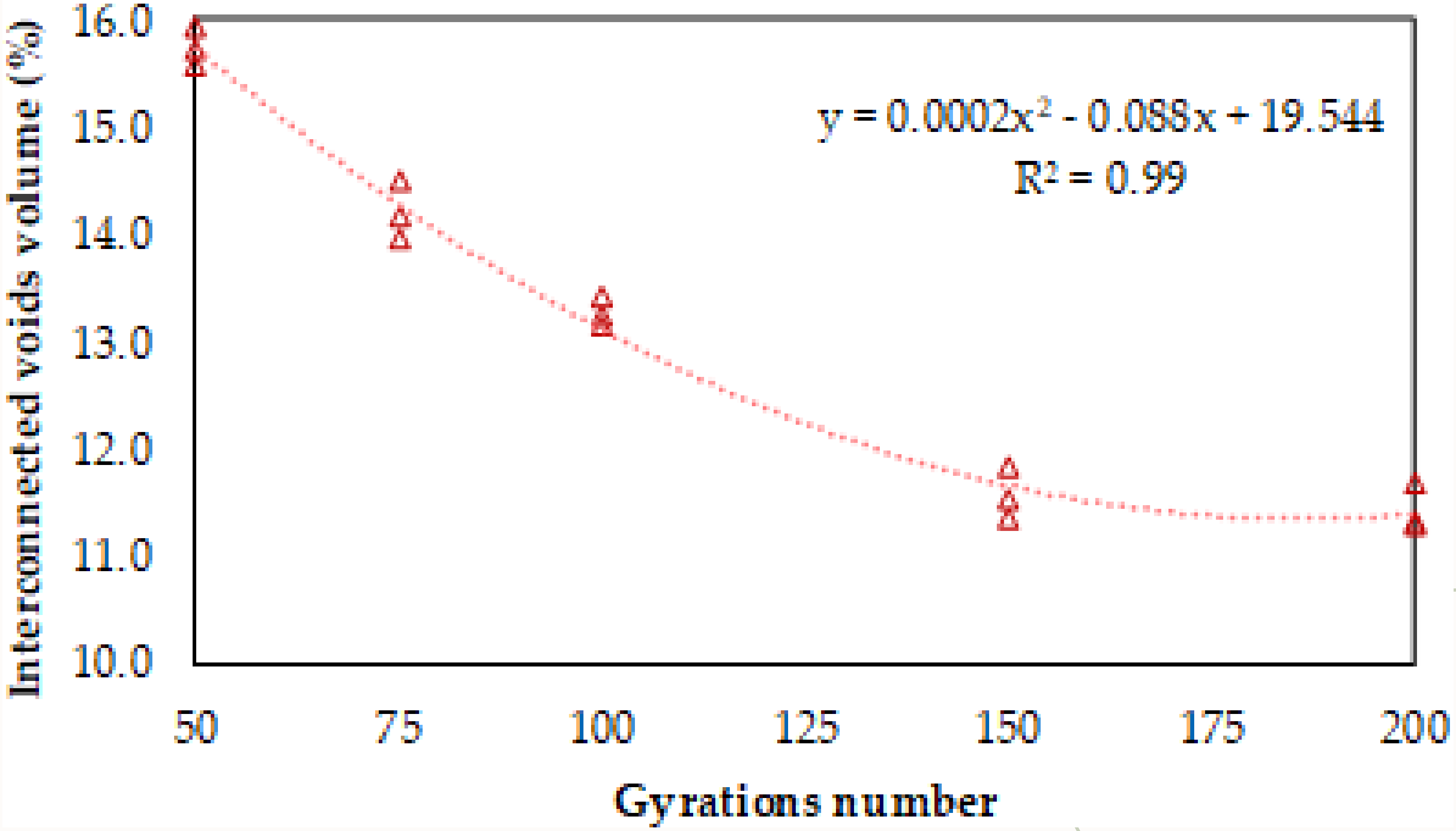
In voids volume, it can be observed that as the level of compaction effort increased, the voids decreased. After 100 gyrations, the voids volume tended to stabilize with average values of 21.34%, 20.76% and 20.62%,for 100, 150 and 200 gyrations, respectively .



RESULTS AND DISCUSSION

Influence of compaction effort in the voids reduction

IThe interconnected voids volume reduction with the compaction effort increase indicated a decrease in permeability. Similarly, there was a tendency for values to stabilize after 100 gyrations, being, on average, 13.25%, 12.63% and 12.23% for 100, 150 and 200 gyrations, respectively.



RESULTS AND DISCUSSION

Influence of compaction effort in the permeability coefficient reduction

The initial permeability coefficients (ki) measured before and the final one (kf), evaluated after simulations. The values were normalised for the permeability coefficient reduction (kr) analysis through the obtained average.
The uncertainty range admitted presented a reliability of 68.3%.

Gyrations number	ki (mm/s) [1]	kf (mm/s) [2]
50	2.95	1.53
75	2.26	0.84
100	1.98	0.64
150	1.01	0.15
200	1.15	0.10

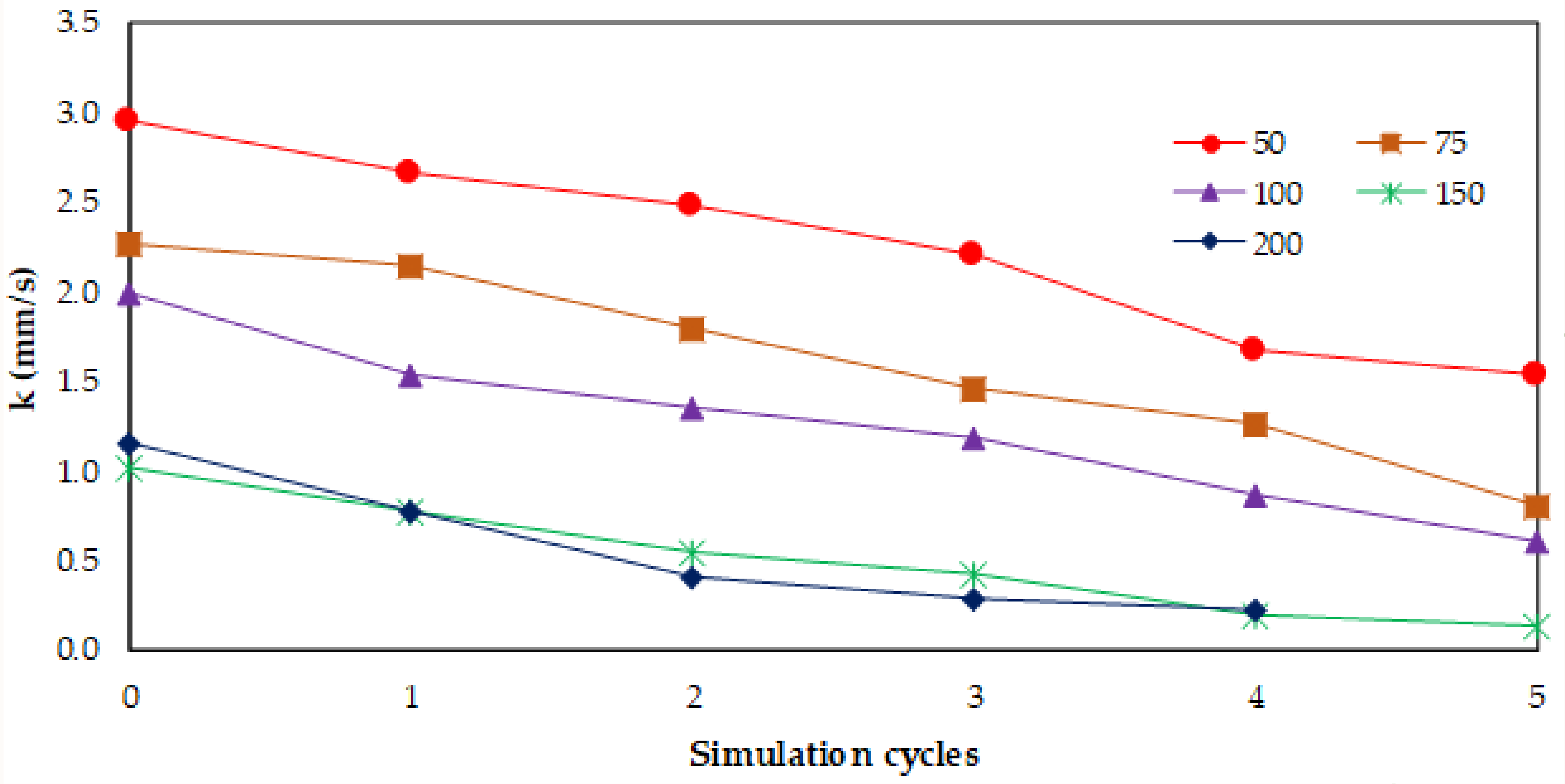
1 Initial permeability coefficient;
2 Final permeability coefficient

RESULTS AND DISCUSSION

Influence of compaction effort in the permeability coefficient reduction

the compaction effort increase, representing the traffic load along the time, is reflected in the permeability coefficient reduction.

In the literature, there is a lack of studies that evaluated clogging at samples submit-ted to different compaction efforts. Samples submitted in simulation cycles using a per-meameter with more than 20% voids were less affected by clogging.



RESULTS AND DISCUSSION

Intervention time

The permeability coefficient reduction (kr) was calculated when the interconnected voids volume reached a value of 12%, and then the intervention time can be estimated

Gyrations number	Vv [1] (%)	IVv [2] (%)	k_{mean} [3] (mm/s)	k_{min} [4] (mm/s)	IT [5] (months)	Precipitation (mm)
50	24.54	15.73	1.53	1.16	14.16	1,853
75	22.28	14.19	0.80	0.68	13.15	1,720
100	21.34	13.25	0.60	0.49	12.64	1,654
150	20.79	12.63	1.01	0.12	10.66	1,395
200	20.68	12.23	0.22	0.21	7.59	994

1 Voids volume; 2 Interconnected voids volume; 3 Mean of permeability coefficient; 4 Minimum permeability coefficient; **5 Intervention time.**

CONCLUSIONS

In order to evaluate the traffic effect over time, the samples were submitted of different compaction efforts in the CGS by gyrations number increase (50, 75, 100, 150, 200 gyrations). The samples were tested in the laboratory by rainwater (runoff solution) cycles through a constant head permeameter developed in the study.

A stabilization of voids volume and interconnected voids volume values were observed from 100 gyrations, indicating that higher compaction levels present slight variations.

A minimum value of 12% of the interconnected voids volume was established, con-sidering that the porous mixture was clogged.

The permeability reduction was proportional to the gyrations increase. For samples subjected to 50 gyrations, the maximum in-tervention time was 14 months.

CONCLUSIONS

For 200 gyrations, considering the effect of traffic, the intervention time was shorter, approximately 7.6 months.

Considering the porous asphalt mixture of this study and the local annual rainfall (1,570 mm), based on the evaluated parameters, it is recommended that the intervention time by surface cleaning (with water and air jets) be carried out at least each year.

Moreo-ver, it is essential for future studies that the mixture's internal structure will be analyzed to estimate the intervention time and permeable parameters measurement.

Also, experimental stretches must be constructed and monitored for data validation. The following research steps involve the development of a stormwater simulator and analysis by tomography.

THANKS FOR YOUR ATTENTION!

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