

A pervious concrete mix design based on clogging performance in Rio Grande do Sul

Liv Haselbach

Fulbright-ALCOA Distinguished Chair in the Environmental
Sciences and Engineering in Brazil

Civil & Environmental Engineering

Washington State University

haselbach@wsu.edu

Vanessa Pasa Dutra

Paulete Schwetz

Luiz Carlos Pinto da Silva

*Laboratório de Ensaios de Modelos Estruturais -
LEME/UFRGS*

Boa tarde!

Part I: What are Permeable Pavements and Pervious Concrete?
(concreto permeável)

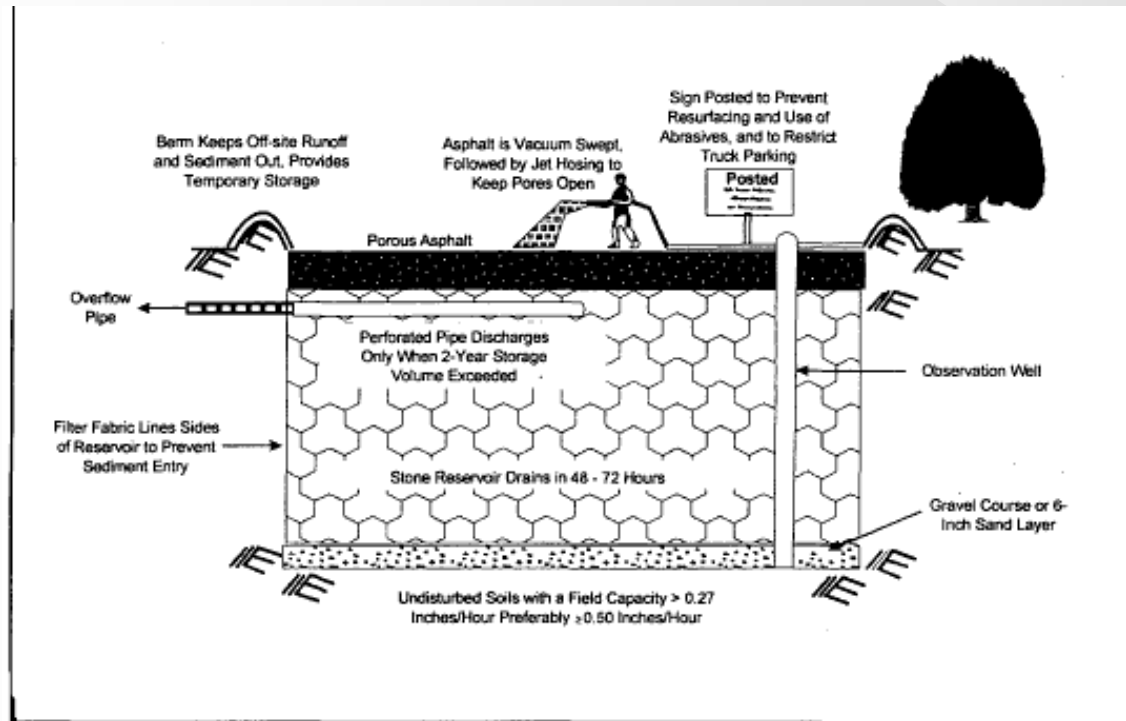
Part II: Pedrisco

Part III: Clogging

Part IV: Sweeping

Part V: Additional Work

Permeable Pavement Systems!



Source: Modified from MWCOG, 1987.

FIGURE 1 TYPICAL POROUS PAVEMENT INSTALLATION

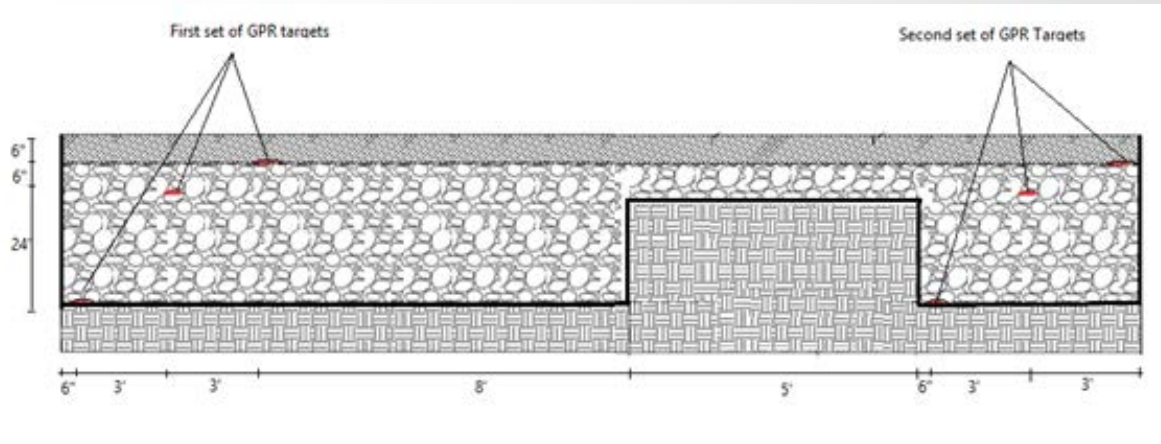
STRUCTURED SURFACE PLUS:

Surface Infiltration

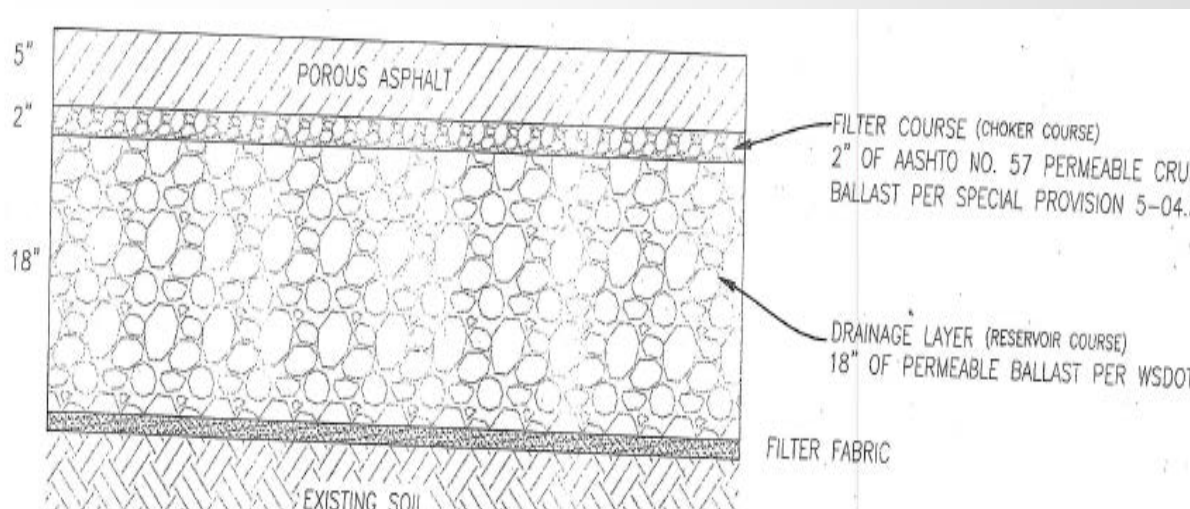
Underground Storage

Pollutant Removal: - on top - in ground - in reservoir - to air?

Permeable Pavement Systems!

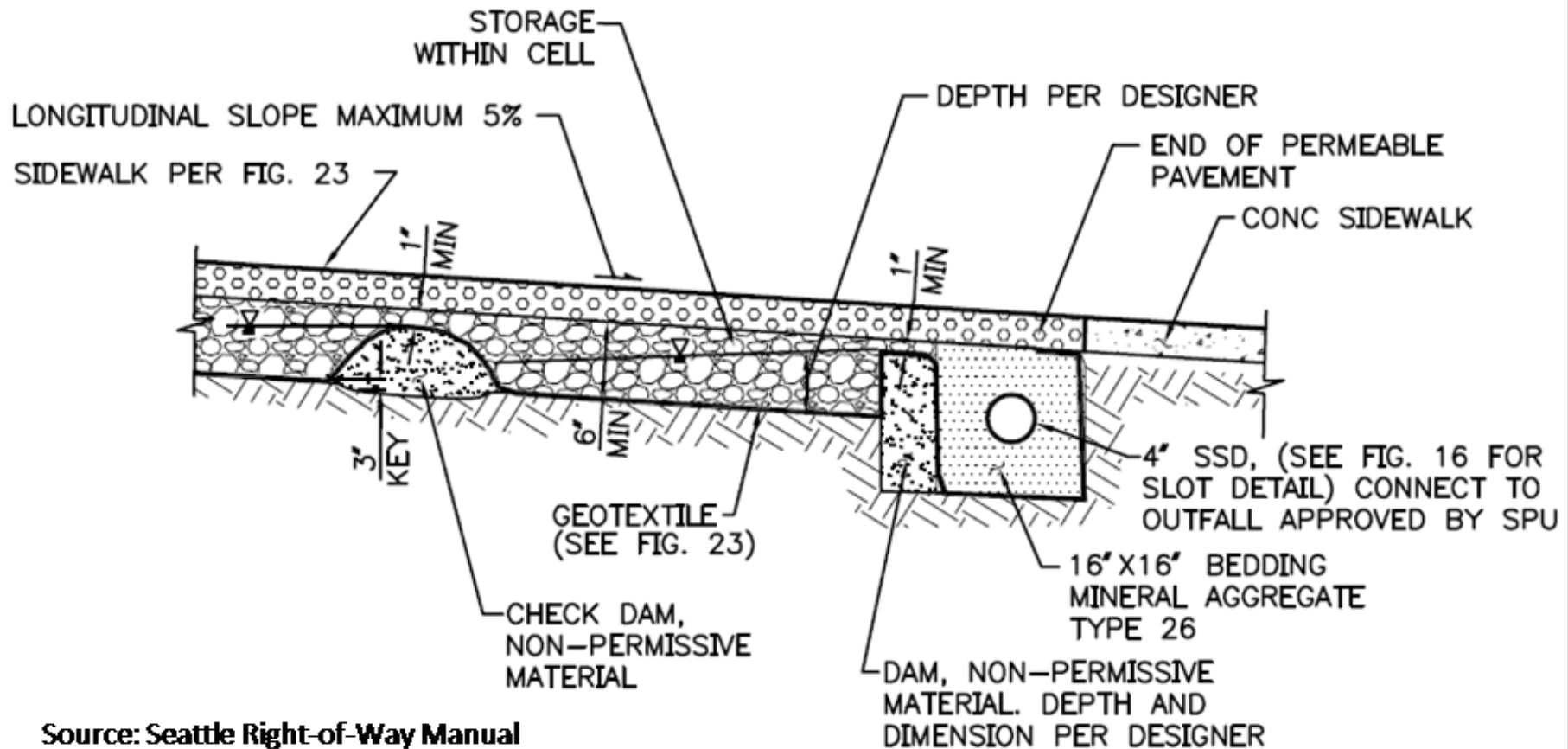


- What depth should the aggregate bed be?
- For structure (loads)
 - For water storage (runon and storms)
 - For frost depth



Permeable pavements on slopes?

Remember it is a **System**



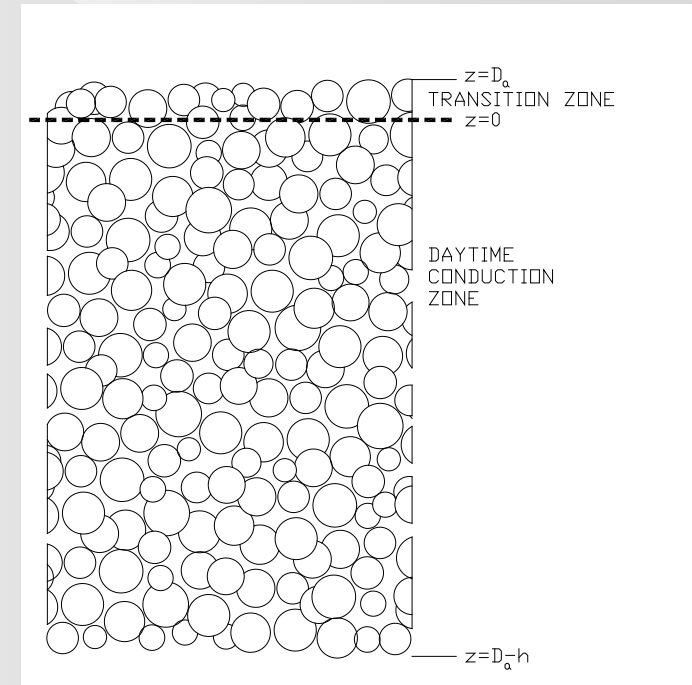
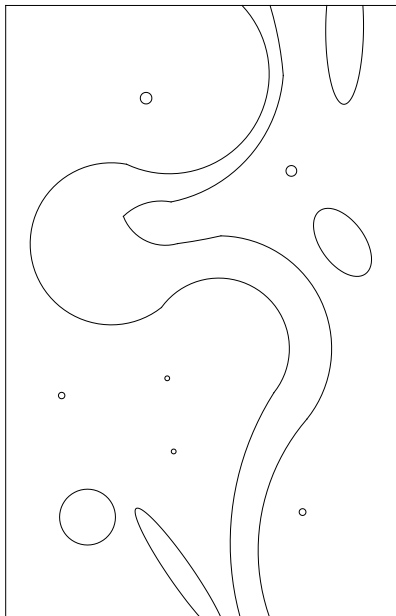
Be careful that the water from surrounding areas (runon) does not flow too fast and overshoot!

What is Pervious Concrete?

Mixture of :

- Coarse aggregate,
- Cementitious material,
- Admixtures, and
- Water.
- Carefully controlled amounts of water & cementitious materials are used to create a paste that forms a thick coating around aggregate particles without flowing off during mixing & placing.

Unique Structure of Pervious Concrete



Vertical Porosity Distribution

- Top Transition Zone
- Micro/Macro Pores
- Connected/Disconnected Pores

Porosity of Pervious Concrete

- Total Porosity Ranges: ~13%-40%
- Recommended: ~20-25%
- Tortuosity (vertical and horizontal flow)
- Compressive Strength(not used for specifying):
Typically 1000-3000 psi. (7-20 Mpa)



How is pervious concrete placed?

Concrete	Traditional	PC
Cement	1	1
Aggregate	3	4+
Water	1/2	~1/3
Fines	2	~0



Mixed



Compacted & Covered



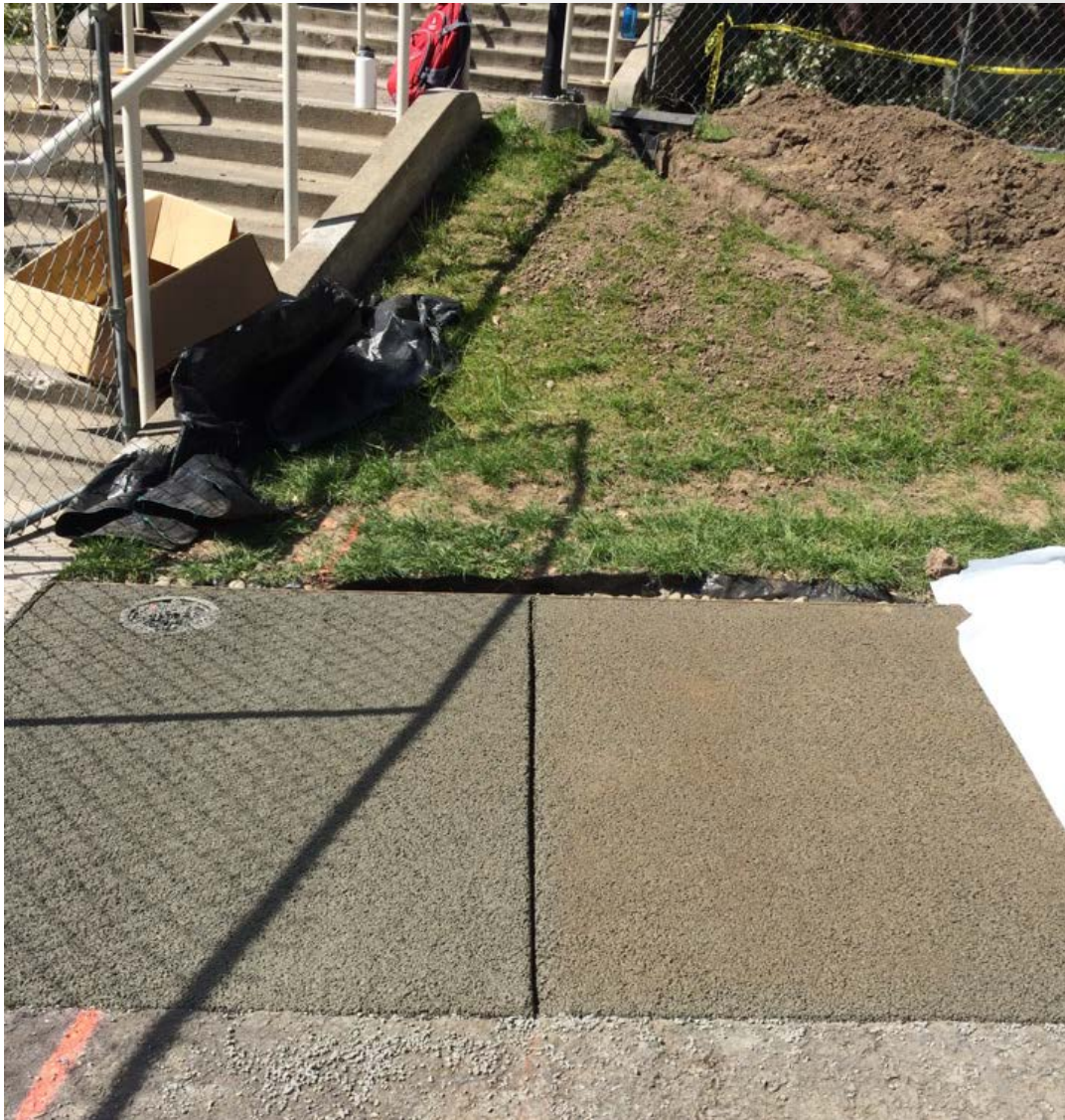
Cured 7 days

Remember Preventive Maintenance

- **Prevention:** During design locate in areas less subject to clogging....limit runoff from certain applications (asphalt, landscape beds, etc....)



Remember Preventive Maintenance

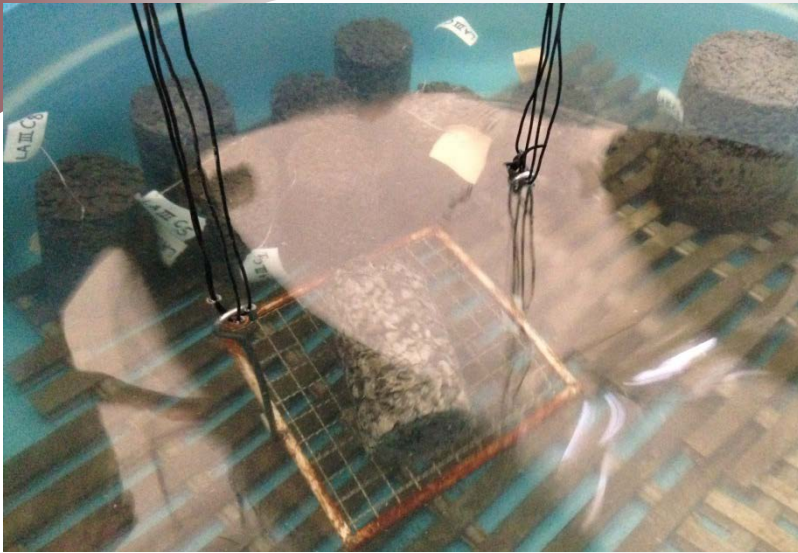


- **Prevention:**
During construction protect from construction sediments
- **Prevention:**
During use, protect from other activities such as construction nearby and soil or snow stockpiling, leaf litter, etc.

Maintenance

- Blowing.....not usually
- Street sweepers/cleaners
- Powerwashing
- Special equipment





The Laboratory



Federal University of Rio Grande do Sul (UFRGS) Porto Alegre, Brazil

Evaluating the Design Mix in Porto Alegre

- Very flat basalt aggregate with lots of fines!!!!
- Sieved (screened)
 - No screening (Mix I)
 - Retained on 6.3 mm (Mix II)
 - Retained on 4.8 mm (Mix III)



Pedrisco



Local aggregate retained on
the 4.8 mm screen

Local aggregate passing
the 4.8 mm screen



Pedrisco

Sieve Size (mm)	Mass Retained (%)	Cumulative Mass Retained (%)
19	0.0%	0%
12.5	0.4%	0%
9.5	10.4%	11%
6.3	38.9%	50%
4.8	19.5%	69%
2.4	19.3%	88%
1.2	5.3%	94%
0.6	2.5%	96%
0.3	2.0%	98%
0.15	1.7%	100%
0.075	0.1%	100%
Bottom	0.0%	100%

Evaluating the Design Mix in Porto Alegre

- Made cylinders (100mm x 180mm)
- Made flats (blocos) and cored (100 mm diameter)
- 4:1 mass aggregate to mass cement



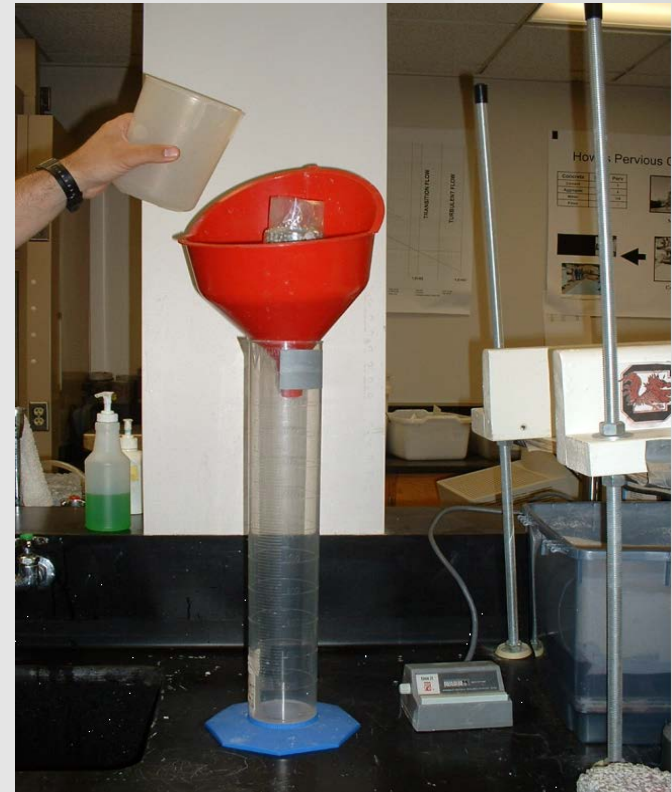
Specimens

Mix	Number of Cylinders	Number of Cores
I (no Sieving)	6	9
II (Retained on 6.3)	6	10
III (Retained on 4.8)	8	10

Mix I would be most economical.
Mix II would be least economical.

ISO 17785-1

- Testing methods for pervious concrete – infiltration rate...
- under development



ASTM C1754

- Standard Test Method for Density and Void Content of Hardened Pervious Concrete
- Montes, Felipe, Srinivas Valavala, Liv M. Haselbach: **A New Test Method for Porosity Measurements of Portland Cement Pervious Concrete**, Journal of ASTM International, January 2005, Vol. 2, No. 1
- Take Mass dry,
- submerge for >30 minutes
- and take mass submerged.....
- Usually want 20-25% with closer to 20 best
- Variability vertically and horizontally



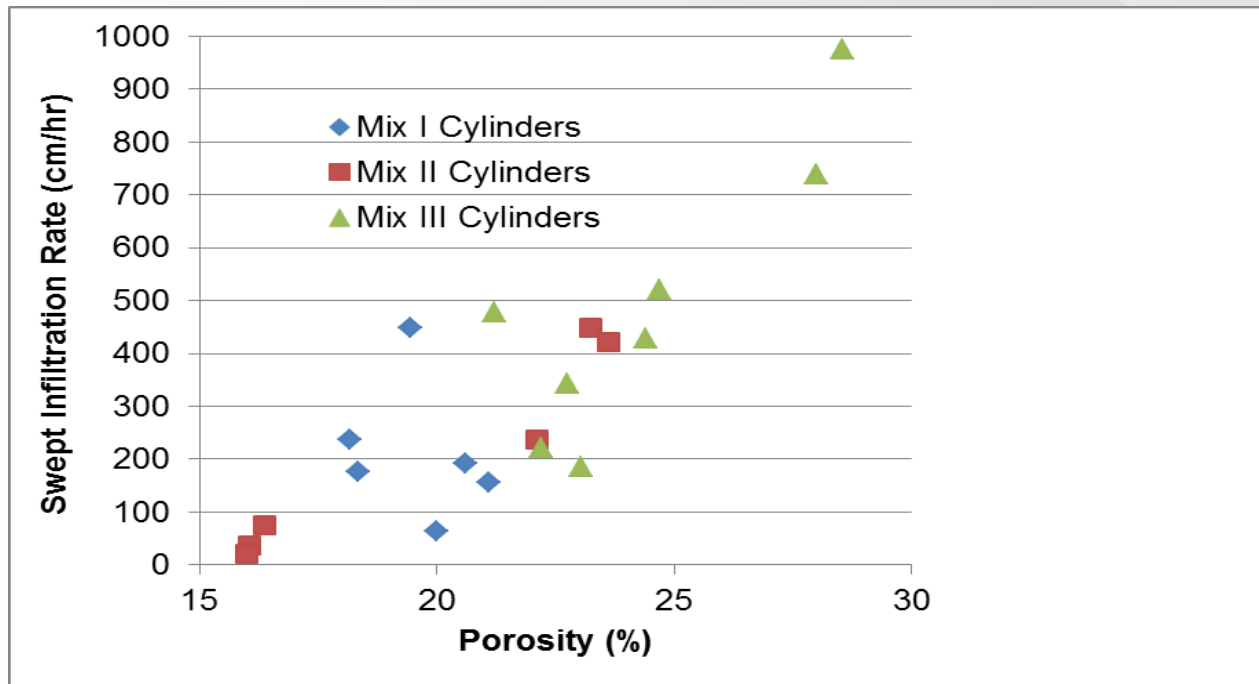
Clogging and Sweeping

- 150 grams of local soil placed on top
- 300 grams of water poured almost each workday (13 times)
- Some specimens totally clogged, others not
- Then 'broke' hardened clay and swept top with brush

Initial versus Swept Infiltration

Cylinders	Mix	Cylinder ID	Porosity (%)	Initial Rate (cm/hr)	Swept Rate (cm/hr)	Ratio Swept/Initial
	I	Average I	19.6	1040	212	0.20
	II	Average II	19.6	1200	207	0.17
	III	Average III	24.4	2160	487	0.23
Cores	Mix	Core ID	Porosity (%)	Initial Rate (cm/hr)	Swept Rate (cm/hr)	Ratio Swept/Initial
	I	Average I	25.0	1840	90	0.049
	II	Average II	26.8	1570	69	0.044
	III	Average III	25.9	1820	93	0.051

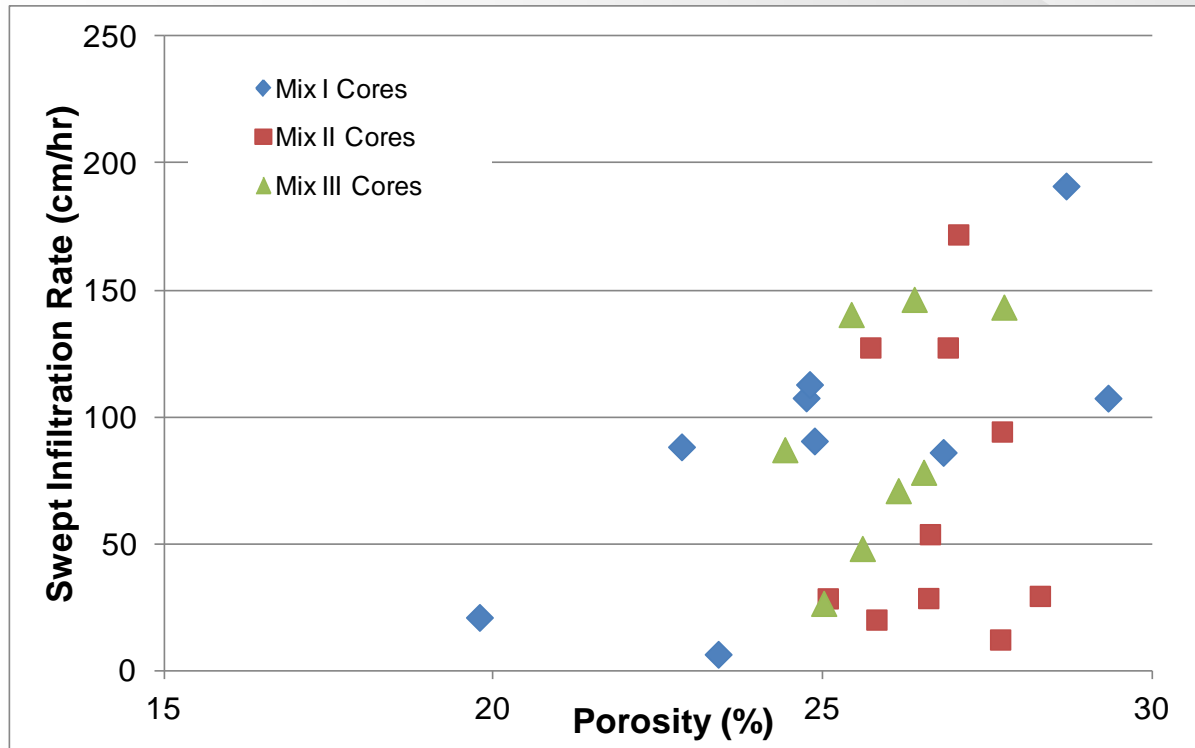
Evaluating the Design Mix in Porto Alegre



Porosity versus Swept Infiltration Rate for the Cylinders

- Haselbach, L., Dutra, V. P., Schwetz, P., Silva Filho, L. C. P., *A Pervious Concrete Mix Design Based on Clogging Performance in Rio Grande do Sul*, Proceedings, 3rd International Conference on Best Practices for Concrete Pavements, "Challenges for the future of sustainable concrete pavement construction", Bonito, Brazil Oct. 28-30 2015, IBRACON – ISSN 2175-8182.

Evaluating the Design Mix in Porto Alegre



Porosity versus Swept Infiltration Rate for the Cores

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Evaluating the Design Mix in Porto Alegre

- Seems like the local rock is fine, even if very flat and with a substantial amount of fines...
- Noticed that when coring, need to relieve pressure on the bottom of the block.. Used palettes
- Coring tends to clog the specimens some so initial infiltration rates are lower for similar porosities than in-situ
- Porosities under 25% tend to regain more of initial rate.. Speculate that the smaller pores keep the larger sediments from going deeper
- Previous testing shows that aggregate to cement up to 5.3 might be fine, but 7 is way too high
- Note that no admixtures were used.

Additional Work

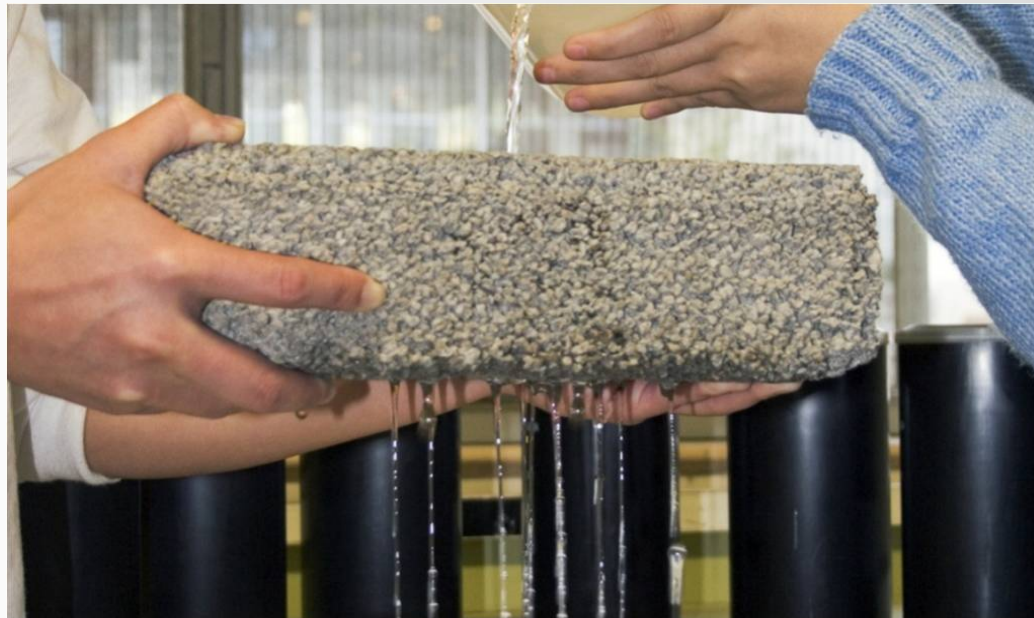
- Powerwashing simulations
- Strength testing
- Other mix designs

(more aggregate less cement: 5:1)

(admixtures)

Obrigada!

?



Testing Methods

- ASTM c1688-14a Standard Test Method for Density and Void Content of Freshly Mixed Pervious Concrete
- ASTM c1701-09 Standard Test Method for Infiltration Rate of In Place Pervious Concrete: ASTM c1747-13 Standard Test Method for Determining Potential Resistance to Degradation of Pervious Concrete by Impact and Abrasion
- ASTM c1754-12 Standard Test Method for Density and Void Content of Hardened Pervious Concrete
- ASTM c1747- Standard Test Method for Determining Potential Resistance to Degradation of Pervious Concrete by Impact and Abrasion
- ISO 17785-1 Testing methods for pervious concrete – laboratory specimens and infiltration rate.....under development

Placement



Placement

- Wet the rock before you place the concrete.



Placement





Placement

Done in seven days!