expanding the realm of POSSIBILITY®

Permeable Pavement Design and Construction Allston Way, Berkeley California

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Overview

- Introduction & Background
- Feasibility Decision Criteria
- Pavement Design
- Construction
- Maintenance
- Lessons Learned

Introduction

- The City of Berkeley wanted to complete a permeable pavement demonstration project
- Allston Way was selected and rehabilitated using a permeable interlocking concrete pavement (PICP)
- Designed by AECOM and ARA
- Opened to traffic October 2014

Introduction

- The problem:
  - Increased flood flows
  - Infrastructure damage
  - Water quality

Permeable Pavements – A Green Solution

- In percolating soils, increases infiltration
- Reduces stormwater volume/peak flows
- Reduces stormwater pollutant load
- Decreases downstream erosion

Porous, Pervious & Permeable Pavements

- Pavements designed to permit the infiltration of surface water

Permeable Pavements

Infiltrate water into the pavement structure

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Provide temporary storage capacity for water in the stone reservoir

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Filter contaminants in the water

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Infiltrate water into the subgrade (where possible)

↓

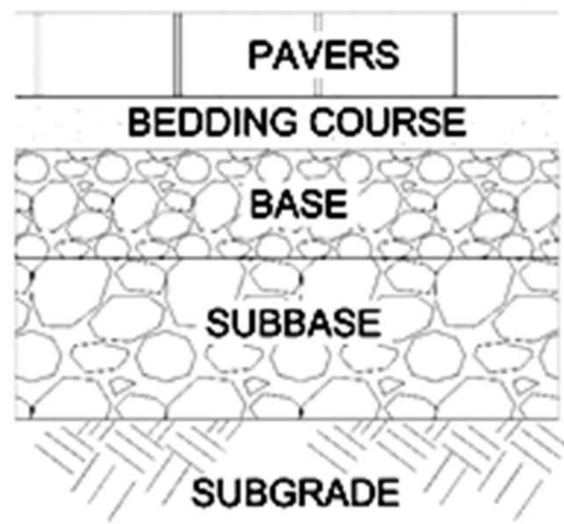
Convey water to appropriate discharge points

↓

Provide flow control for water leaving stone reservoir

Permeable Interlocking Concrete Pavement (PICP)

- Advantages
  - Ease of construction
  - High surface infiltration options
  - Hard durable surface, 55 Mpa (8,000 psi)
  - Aesthetics
  - Ease of maintenance and repair
- Disadvantages
  - Typically higher cost
  - Limited to lower-speed roadways



Feasibility Decision Criteria

- **Step 1 – Evaluate acceptability**
  - Are they permitted by national and local regulations
- **Step 2 - Evaluate opportunities and drivers**
  - Incentives (financial, environmental benefits, sustainability achievement)
  - Requirements to reduce the volume of stormwater runoff, reduce peak runoff flowrates, improve the quality of stormwater runoff
  - Potential for reduction in future stormwater management costs by modifying pavement design for stormwater management
- **Step 3 - Evaluate benefits, risks, and technical design factors**

Suitability Design Matrix

- Primary Considerations
  - Significant longitudinal grades (>5 percent)
  - Geotechnical risks
  - Presence of utilities
  - Traffic volume
  - Presence of bike paths

Suitability Design Matrix

- Secondary Considerations
  - Groundwater contamination risk
  - Soil infiltration rates
  - Potential for sediment/biomass loading
  - Target design volumes and runoff
  - Risk of flooding

Suitability Matrix

A.	Primary Considerations		Part A Weighting:60	
	Consideration	Score	Weighting	Weighted Value
1	Significant Longitudinal Grades	High	20.0	20.0
2	Geotechnical Risks	High	15.0	15.0
3	Presence of Utilities	Low	25.0	5.0
4	Traffic Volume (ADT)	High	20.0	20.0
5	Presence of Bike Paths	High	20.0	20.0
	Part A Total		100.0	80.0
			Weighted Total A:	48.0
B.	Secondary Considerations		Part B Weighting:40	
	Consideration	Score	Weighting	Weighted Value
6	Groundwater Contamination Risk	High	20.0	20.0
7	Soil Infiltration Rates	Low	20.0	4.0
8	Potential for Sediment/Biomass Loading	High	20.0	20.0
9	Target Design Volumes and Runoff	Medium	20.0	12.0
10	Risk of Flooding	High	20.0	20.0
	Part B Total		100.0	56.0
			Weighted Total B:	22.4
			TOTAL SCORE	70.4

Initial Candidate Review

Site No.	Location	Primary	Secondary	Total	Evaluation
1	Center Street	43.2	28.8	72.0	Can Consider
2A	Addison Street West	44.4	28.8	73.2	Can Consider
2B	Addison Street East	26.4	25.6	52.0	No
3	Hopkins Triangle	44.4	25.6	70.0	Can Consider
4A	Cedar Street West	21.6	25.6	47.2	No
4B	Cedar Street East	40.8	25.6	66.4	Can Consider
5	Hopkins Street	40.8	25.6	66.4	Can Consider
6	Warring Street	26.4	25.6	52.0	No

On review of potential other candidates, a section of Allston Way in the downtown area was selected with an overall rating of 81

Allston Way

Permeable Pavement Design

- Structural design:
  - Determines various layer thickness necessary to support intended traffic while protecting the subgrade from permanent deformation.
- Hydrological design:
  - Determines key design elements necessary to infiltrate rainwater and surface runoff into the pavement to hold and/or detain and filter the water to achieve stormwater management objectives.

The goal is to optimize the design so that it is just strong enough to support traffic and has the minimum hydrological features to provide water quality/quantity management.

Permeable Pavement Design

- Traffic
  - A limited traffic study was completed
  - Traffic counts were completed for three 24 hours periods
  - Annual average daily traffic for the three days was 4,836
  - 3.9 percent were heavy vehicles

Permeable Pavement Design

- Structural Design Parameters
  - Subgrade Type = Lean Clay with Sand
  - Subgrade Permeabilty = 0.65 in/hr
  - Subgrade R-Value = 5
  - Permeable Paver Surface Infiltration Rate = 6 in/hr
  - Initial Serviceability = 4.2
  - Terminal Serviceability = 2.8
  - Reliability = 80 percent
  - Standard Error = 0.44
  - Paver + Bedding Layer Coefficient = 0.3
  - ASTM No. 57 Base Layer Coefficient = 0.09
  - ASTM No. 2 Subbase Layer Coefficient = 0.06
  - 20 Year Service Life Design ESALs = 370,673
  - 30 Year Service Life Design ESALs = 556,010

Permeable Pavement Design

- Design Pavement Structures

  20 Year Service Life

  3 1/8 in Permeable Paving Stones

  2 in ASTM No. 8 Bedding Stone

  4 in ASTM No. 57 Base

  28 in ASTM No. 2 Subbase

  30 Year Service Life

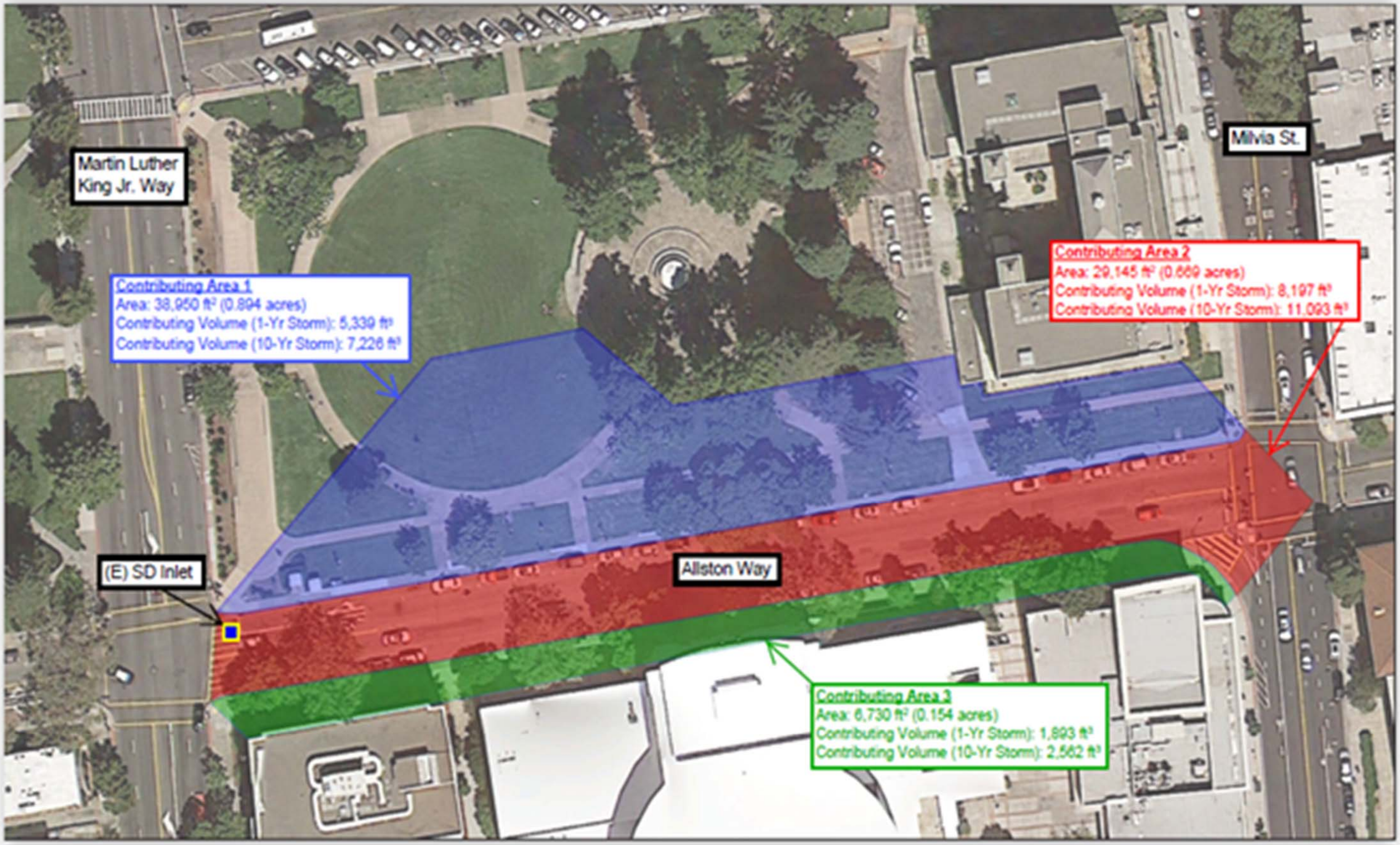
  3 1/8 in Permeable Paving Stones

  2 in ASTM No. 8 Bedding Stone

  4 in ASTM No. 57 Base

  32 in ASTM No. 2 Subbase

Permeable Pavement Design



Permeable Pavement Design

- Site Characterization
  - Pavement surface area = 29,145 ft^2
  - 3 areas sloping towards the pavement

Contributing Area	Surface Texture	Surface Area (ft^2)
Park area to the north	Grass	29,113
Park area to the north	Hard surfaced walkways	9,735
Sidewalk to the south	Concrete walkway	6,730

Water Volumes

Storm Return Period (year)	Rainfall (in)	Volume (ft^3)	Contributing Area Run-on (ft^3)	Total Water Volume (ft^3)
2	2.3	5,586	4,671	10,257
5	2.9	6,946	6,387	13,334
10	3.3	7,893	7,635	15,528
25	3.8	9,278	9,514	18,792
50	4.3	10,347	11,001	21,348
100	4.7	11,415	12,512	23,927

Design: 10 year storm return period

Additional Drainage Details

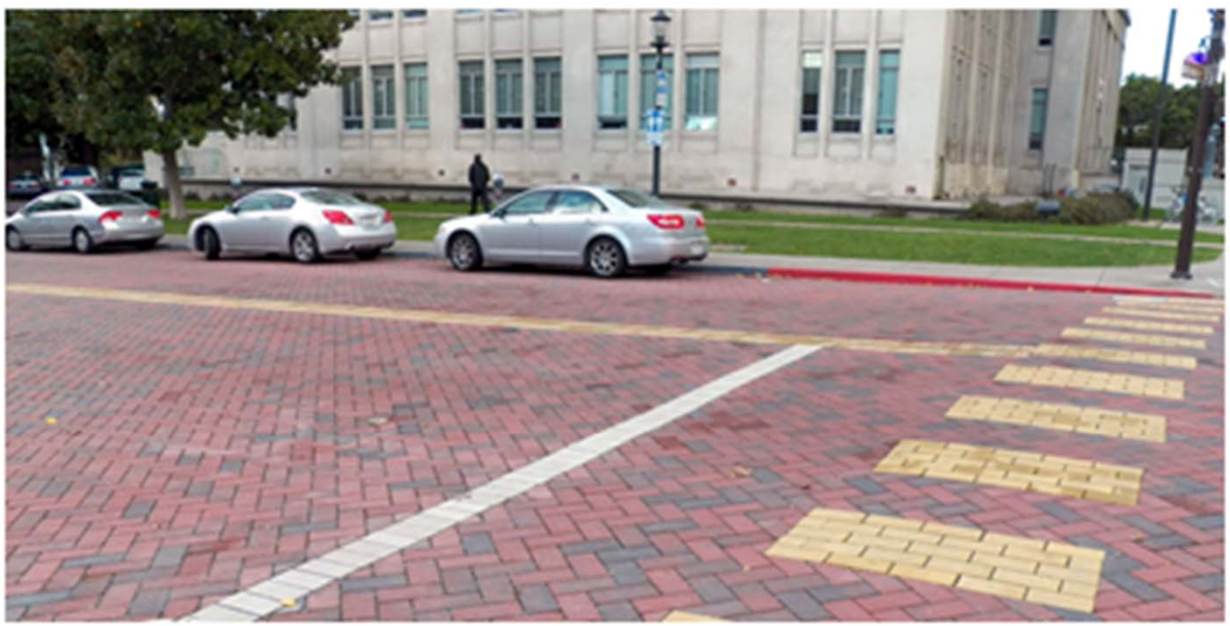
- Subsurface berms
  - Control the volume of water flow within the pavement structure
  - Promote water infiltration into the subgrade
- Underdrains
  - Pavement average transverse slope = 2 percent
  - Maximum distance to an underdrain pipe = 24 ft
  - Drainage area per pipe = 14,572 ft^2
  - Pipe diameter = 6 in
  - Distance from pipe to bottom of subbase = 5 in
  - Pipe slope = 2 percent
  - Roughness coefficient of the pipe = 0.024

Permeable Pavement Design

- Both 20 year and 30 year pavement cross sections were sufficient
- Majority of water volume infiltrated into subgrade
- Remainder of water volume channeled to City storm drainage system

Pavement Construction

- Went smoothly
- Completed in approximately 5 months
- Roadway section closed to traffic
- Several "surprises"
- Open and under traffic since October 2014

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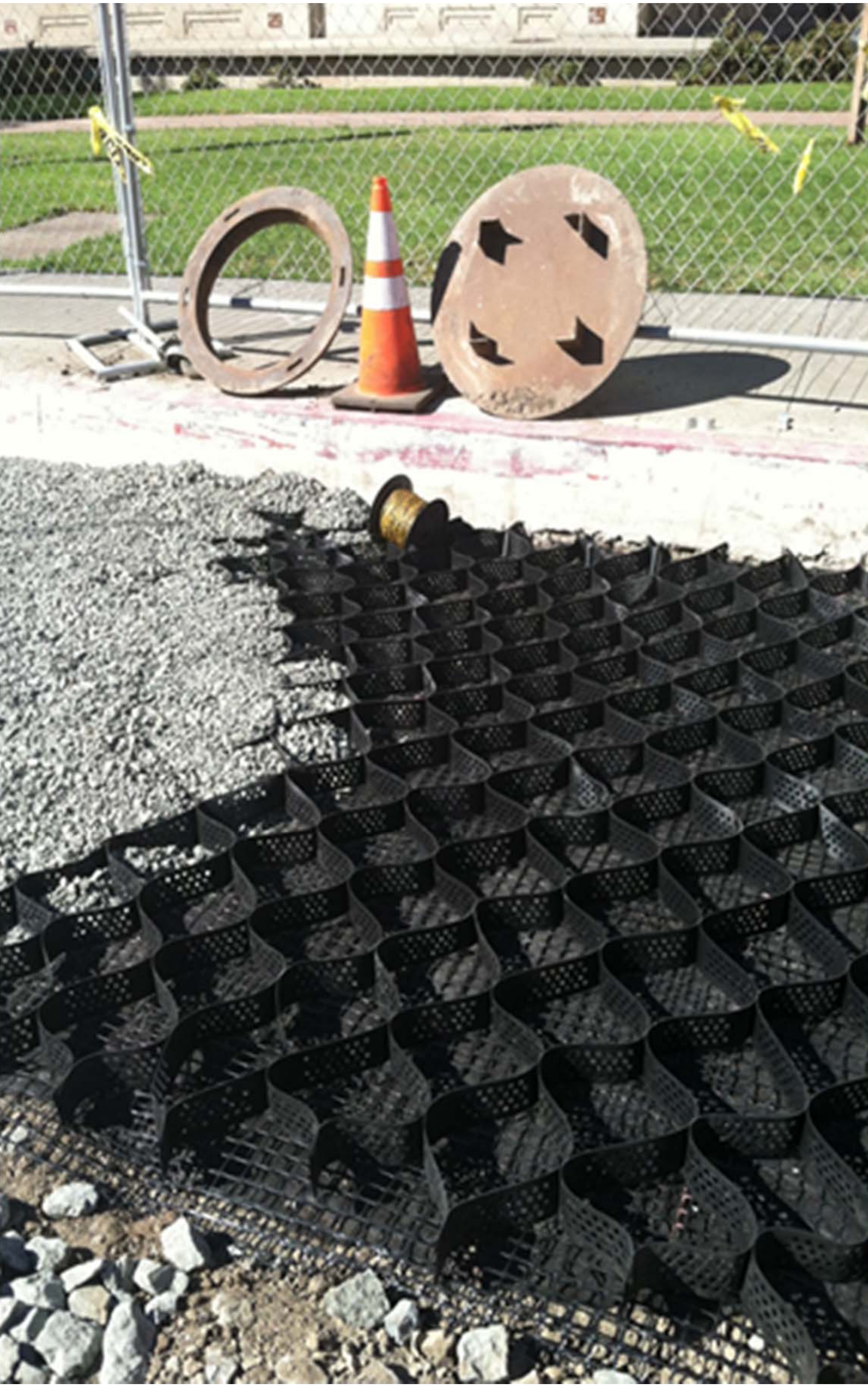
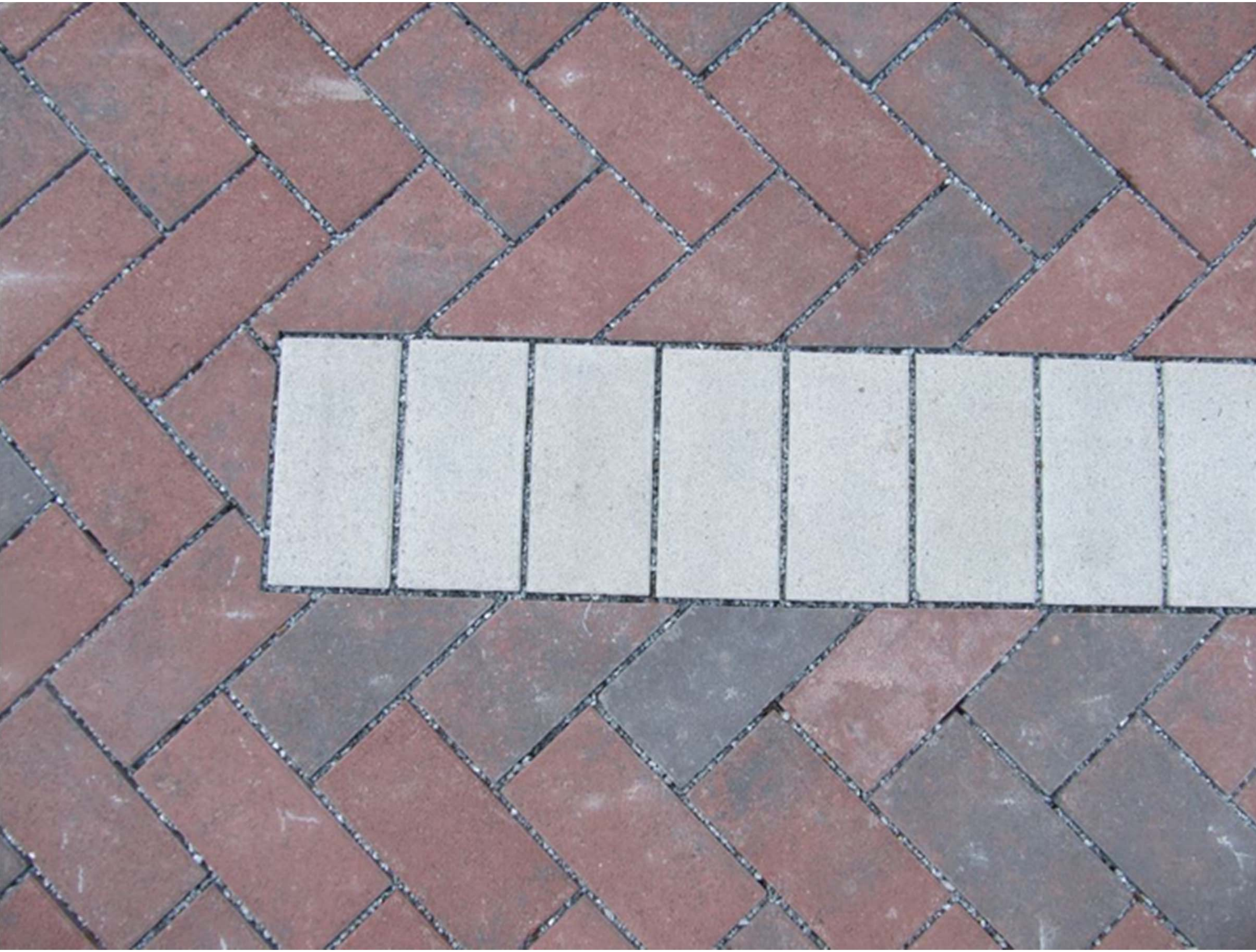



Permeable Surface
Open Graded Base
Open Graded Subbase
Subgrade


PAVESTONE




ELITE GLASS

Pavement Condition Monitoring

- Maintenance manual and procedures developed for post-construction pavement and water quality monitoring:
  - Settlements (10 ft straight edge), joint aggregate, broken or cracked pavers, water quality

Maintenance Action

- Top up of joint aggregate within 6 months of initial construction

Maintenance Action

- Resetting pavers in areas of localized settlements

Maintenance Action

- Resetting pavers in areas of localized settlements

Maintenance Action

- Replacement of damaged pavers

Maintenance Action

- Resetting around Utility Covers

Lessons Learned

- Complete a thorough evaluation of PICP suitability
- Evaluation criteria different for different agencies and priorities
- Carefully consider utilities and existing tree growth
- Closing the roadway assisted in high quality product
- Good and simple specifications are of paramount importance
- Training of operations staff in pavement maintenance and utility cuts is important
- Pavement quality and water monitoring program assists in showing the benefits of permeable pavement


Thank you
Questions?