Permeable Interlocking Concrete Pavements

Program 000003

ICPI
INTERLOCKING CONCRETE PAVEMENT INSTITUTE ®

Revised 1-29-08

Permeable Interlocking Concrete Pavements

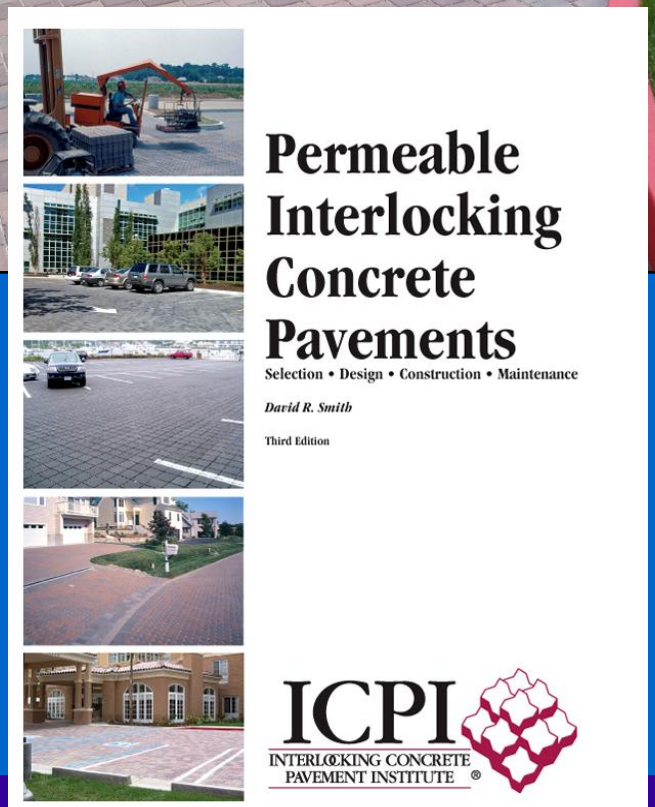
ICPI
INTERLOCKING CONCRETE PAVEMENT INSTITUTE ®

CONTINUING EDUCATION AIA

ASLA CPE

This program is registered with the AIA/CES and ASLA CPE for c education professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA or ASLA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

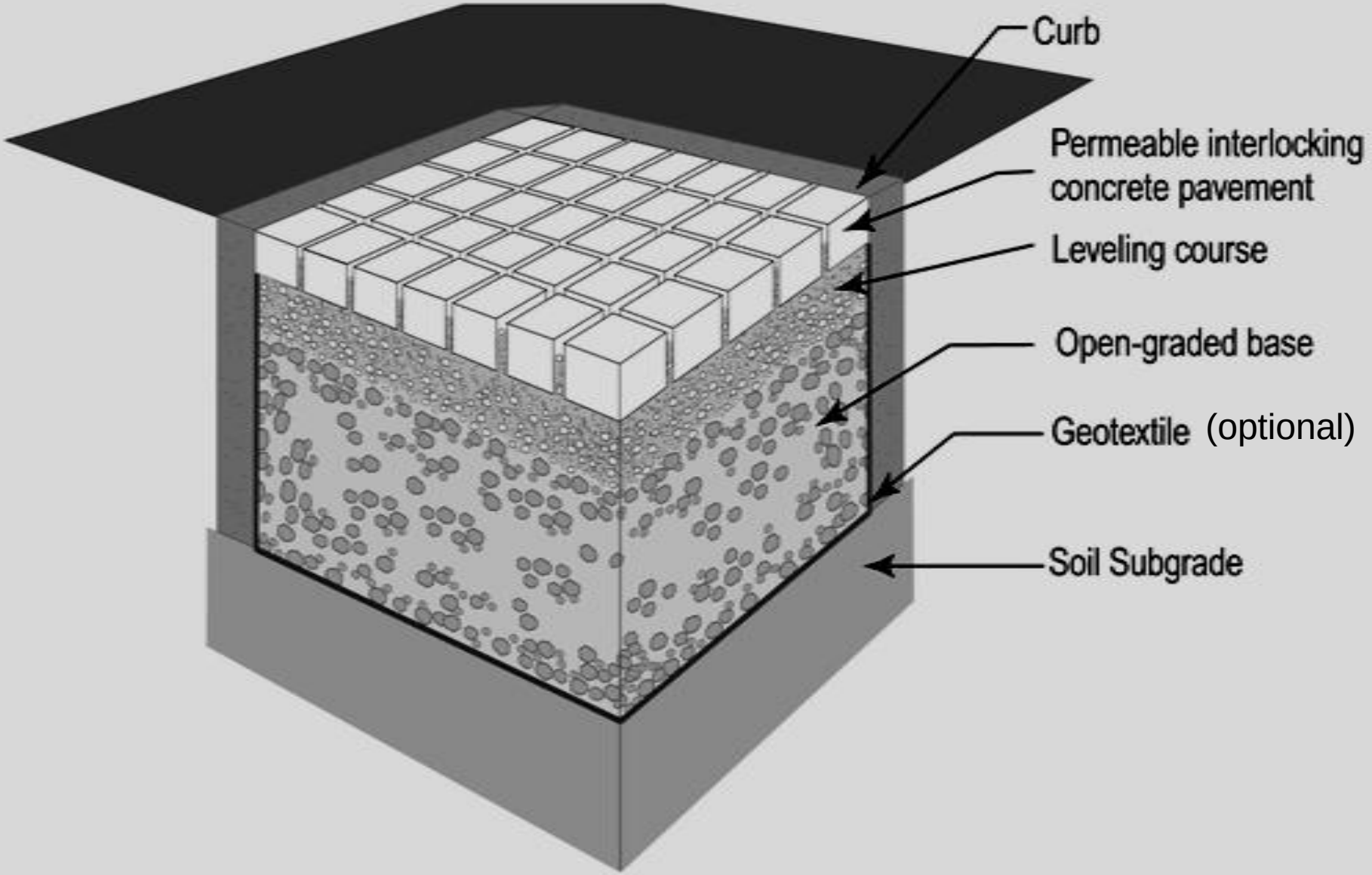
Program 000003



Learning objectives:

- Know how to select PICP
- Understand types of exfiltration options for the base and when each are applied
- Understand the hydrological and structural design principles for the pavement base
- Know the components of a PICP construction specification
- Understand maintenance requirements of PICPs

PICP System Components



Stormwater Management Objectives

Some Approaches…

Retain/infiltrate increased volume & flows

- **Capture first flush, e.g. first ½-1 in. (13 mm)**
- **Control specific nutrients, metals**
- **Imitate pre-development conditions**
- **Capture percentage of storms**

Permeable pavements address all approaches

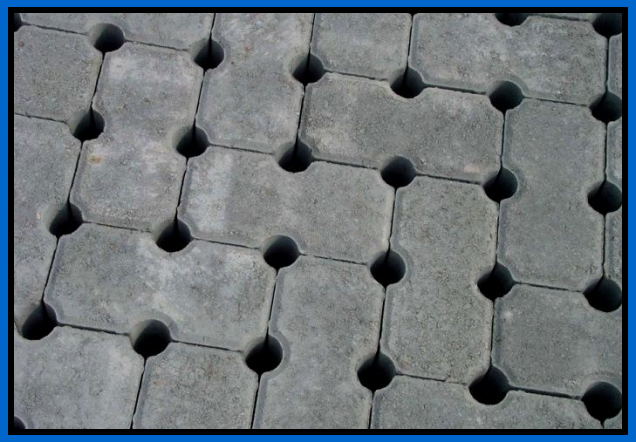
Why Use Permeable Pavers?

Benefits

- **Part of BMP mix; supports LID**
- **Conserves space: pavement on detention facility**
- **100% runoff reduction for high frequency storms**
- **Reduce retention/detention, drainage fees**
- **Filter and reduce nutrients, metals**
- **Increase groundwater recharge**

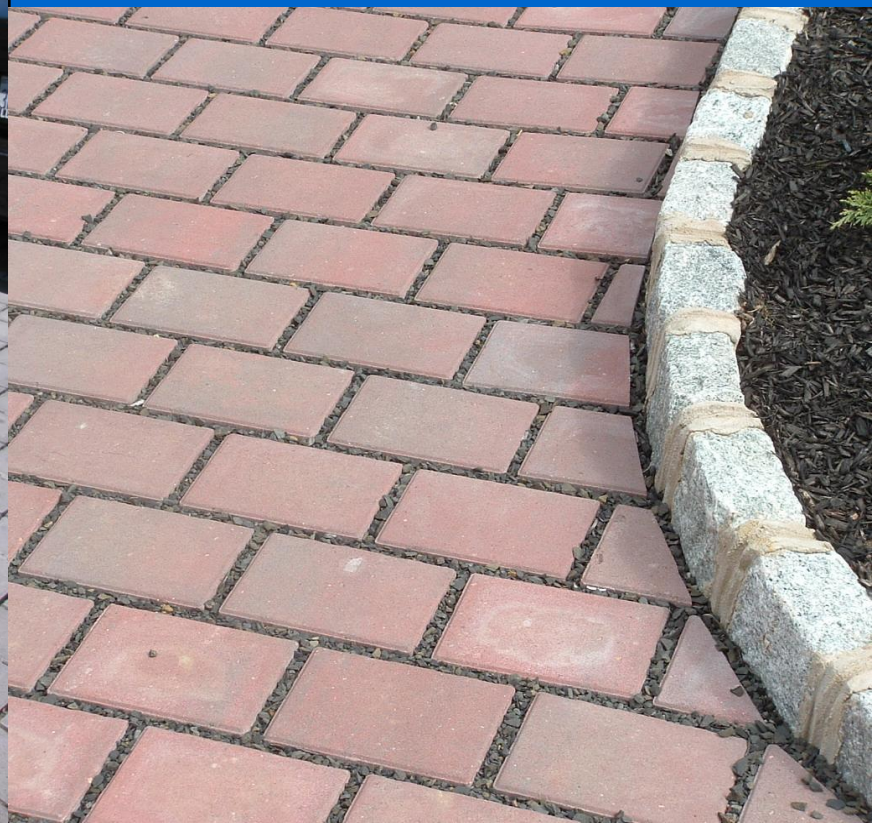
Paver Types

Interlocking shapes/patterns



Paver Types

Enlarged Joints: 10 mm



Paver Types

Porous concrete units

- **Zero fines concrete**

- **For non-freezing climates**
- **Surface: high clogging potential**
- **Install with enlarged joints for additional drainage**

Application Guide for Permeable Segmental Concrete Pavements

	Interlocking Shapes w/openings	Enlarged Joints & Spacers	Porous Concrete Units	Grid Pavers w/Grass
Low speed Roads	Contact manufacturer	Contact manufacturer	Contact manufacturer	Contact manufacturer
Parking lots Driveways	Excellent	Excellent	Not Recommended	Acceptable for low use
Overflow parking, fire lanes	Excellent	Excellent	Not recommended	Good
Revetments Boat ramps	Good	Good	Not Recommended	Good
Bike paths, Sidewalks	Good	Good	Excellent	Not Recommended

Site Opportunities

No space for parking & detention pond

40%+ impervious cover / urbanized uses

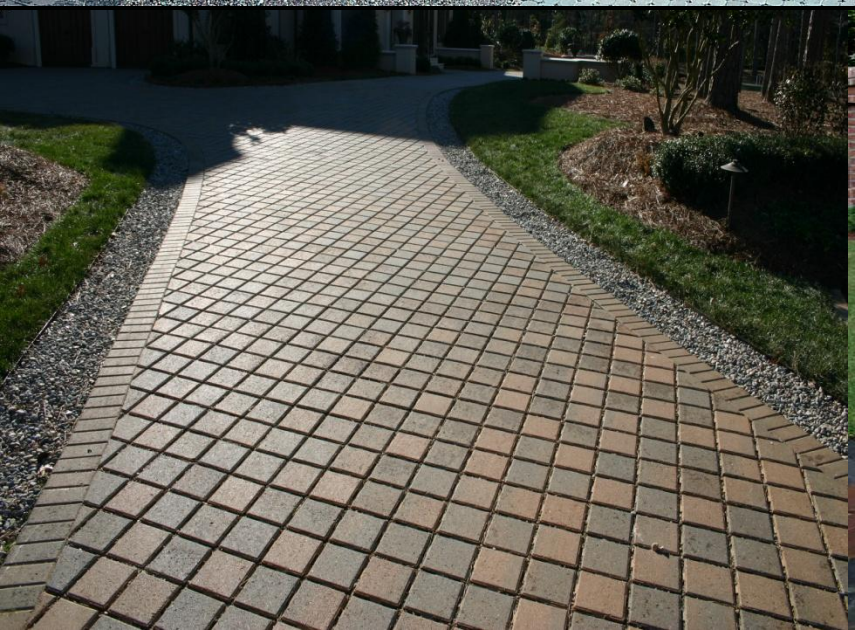
Storm sewer system near/at capacity

Impervious cover limitations

Contributing drainage area

Project Examples

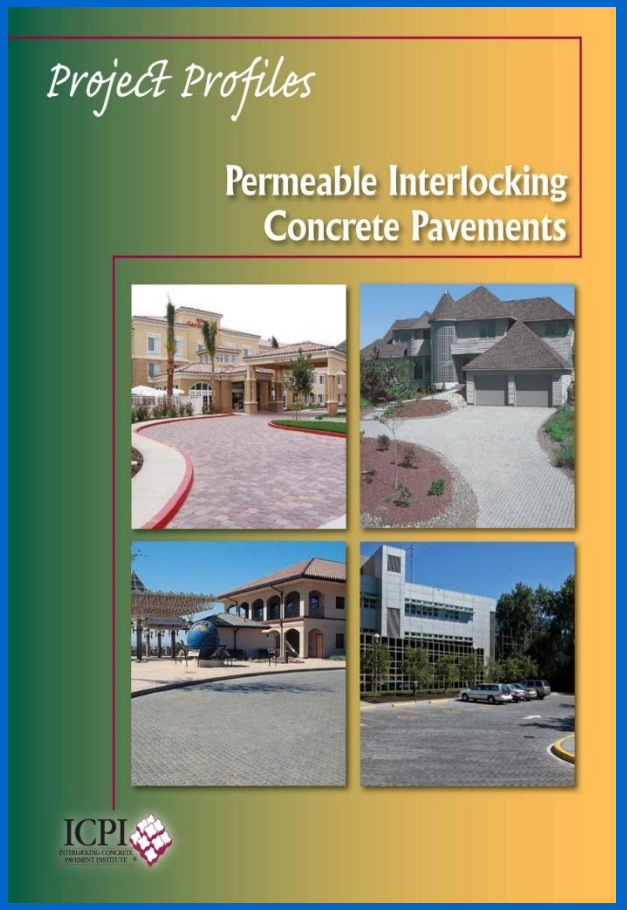
Residential Driveways



Residential roads

Cul-de-sacs in residential roads

Glen Brook Green Subdivision
Waterford, CT
Jordon Cove Watershed
US EPA Section 319 NMP




Entrance drives
WATER CONSERVATORY
GARDEN & LEARNING CENTER
Welcome
Rio Vista Water Plant
Santa Clarita, CA

Hilton Garden Inn
Calabasas, CA

Boat ramp

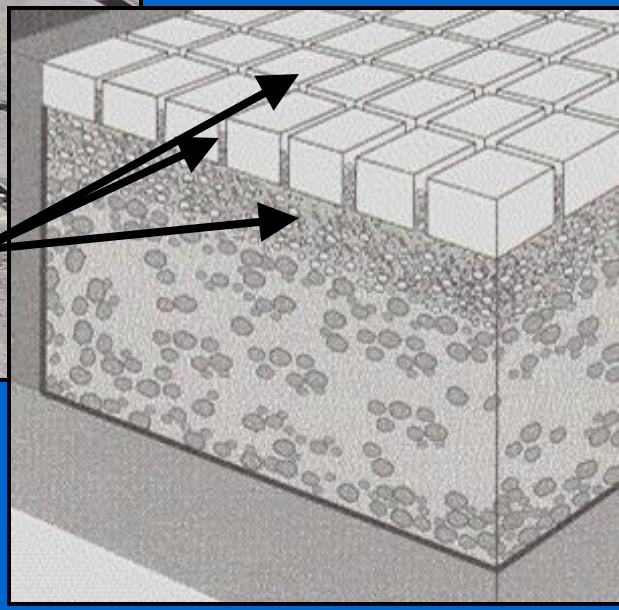
Tree preservation


Somerset Street
Ocean City, MD

Parking lots

Lowe’s Home Center
Olympia, WA

Infiltration Rates
Surface, Joints & Bedding



Void ratio, 8% to 18%

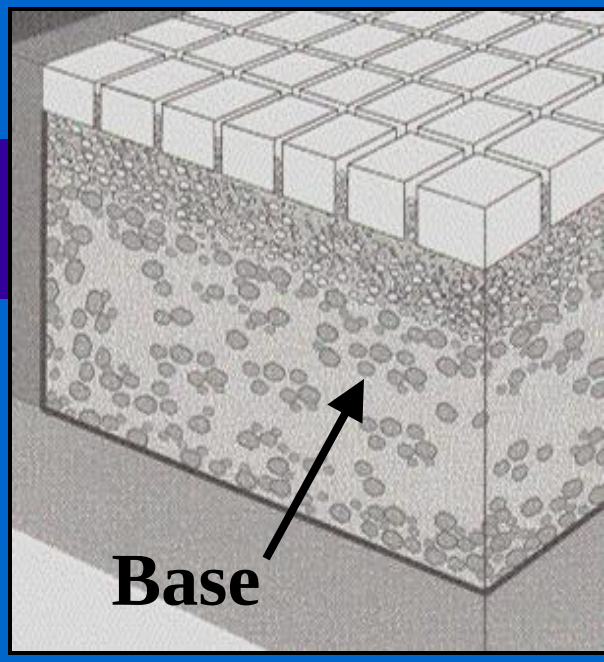
Required infiltration rate of openings:

- Design storm, in. per hr / 0.08
- Example: 2 in. per hr / 0.08
- Required infiltration rate = 25 in./hr

Infiltration rate of stone in openings: 300 to 500 in./hr

Assume 10% lifetime efficiency: 30 to 50 in./hr

Base Storage Capacity



Base materials

No. 57 crushed stone base or similar

1.5 - 1/8 in. aggregate

No. 2 crushed stone subbase or similar

2½ in. – ¾ in. aggregate

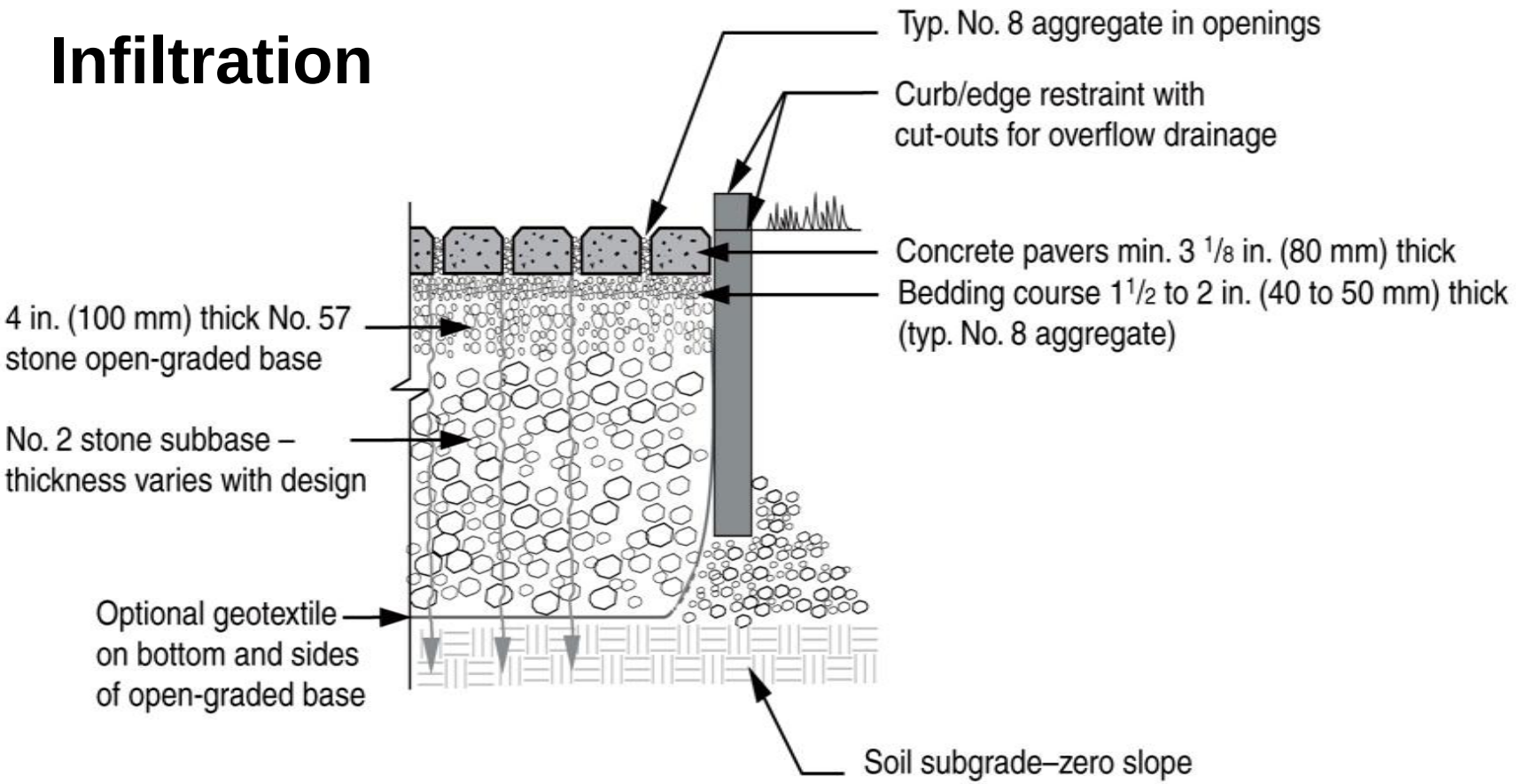
~ 30% to 40% void space

2.5 to 3 in. of base stores about 1 in. of water

Design for 24 - 72 hour storage

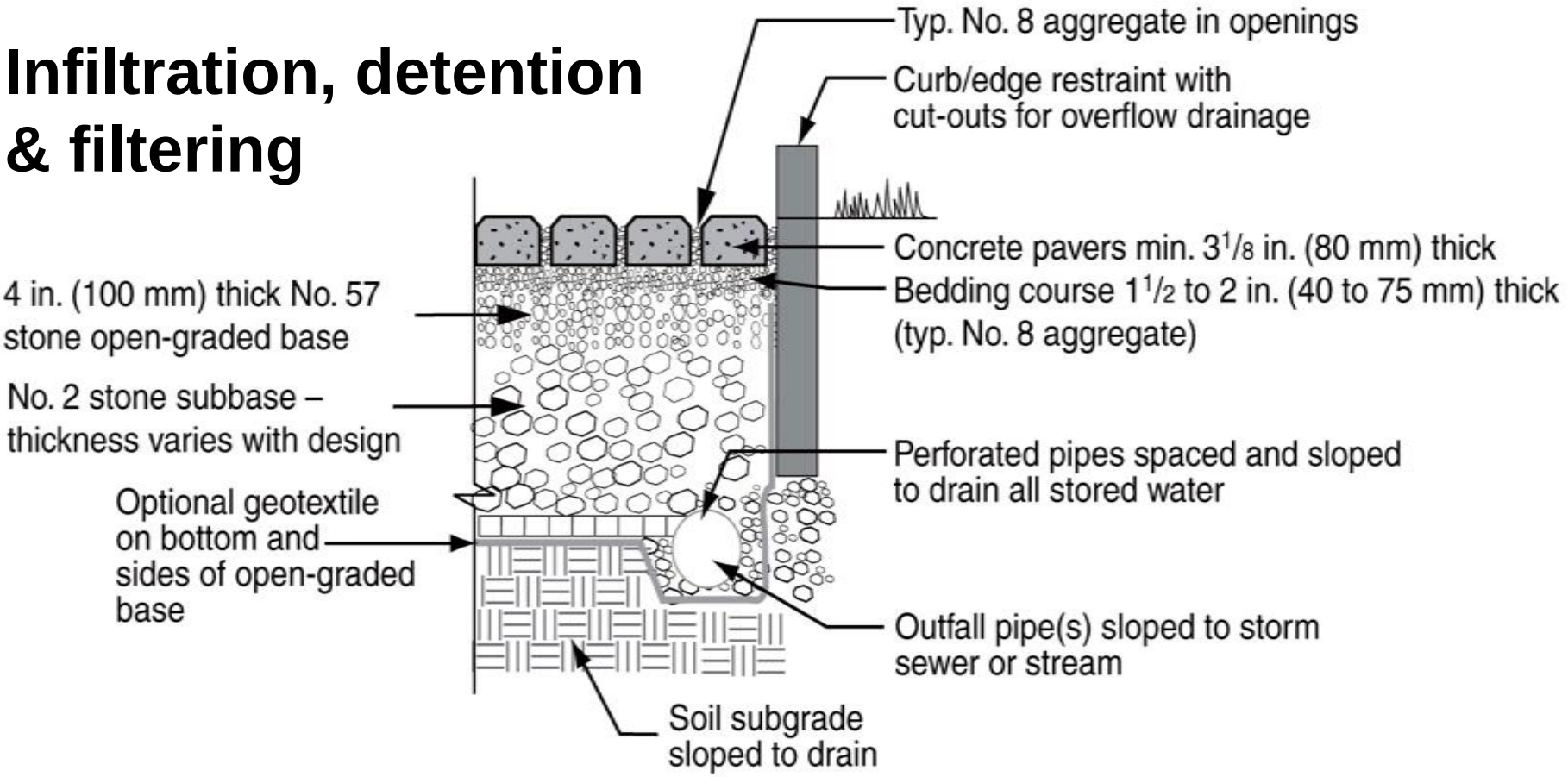
1. Full Exfiltration – Figure 12

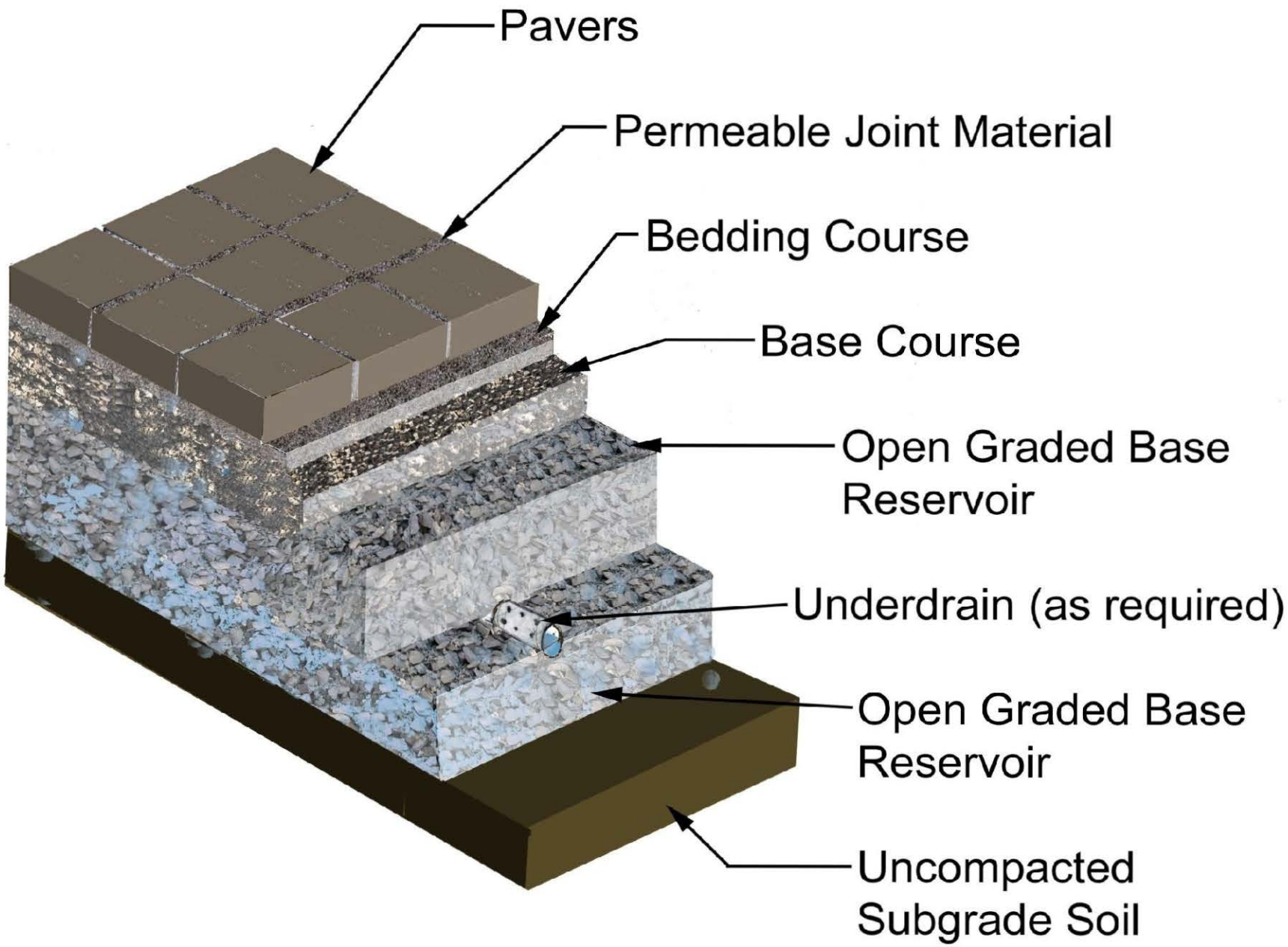
Infiltration



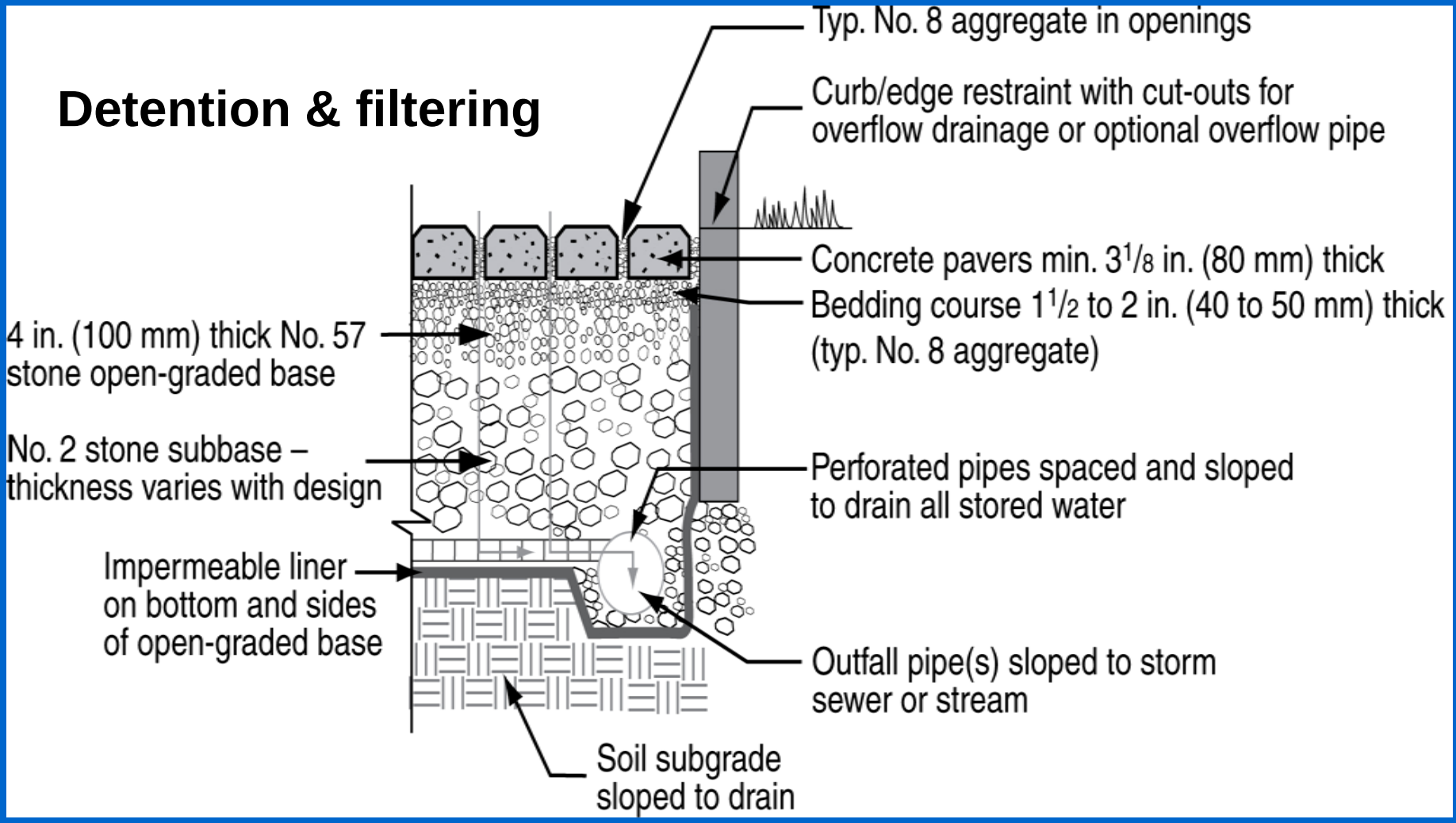
2. Partial Exfiltration – Figure 13

Infiltration, detention & filtering

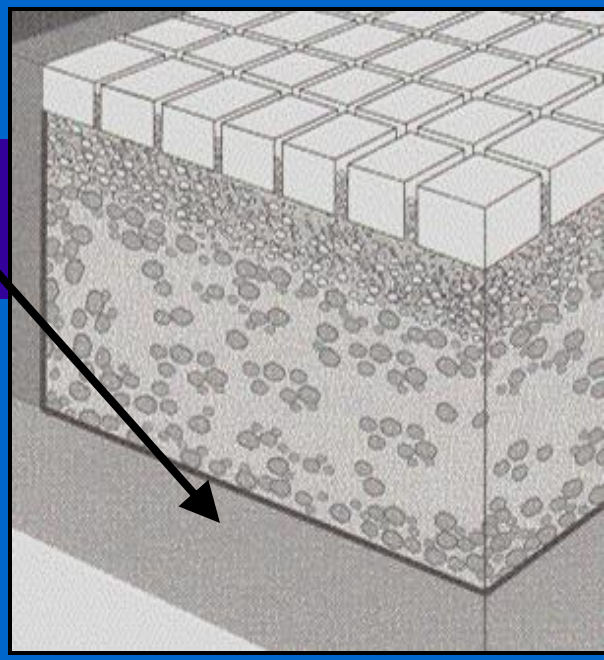



Pavers
Permeable Joint Material
Bedding Course
Base Course
Open Graded Base Reservoir
Underdrain (as required)
Open Graded Base Reservoir
Uncompacted Subgrade Soil

3. No Exfiltration – Figure 14



Soil Infiltration



Establish suitability

Soil maps

NRCS soil classification (ABCD)

USCS soil classification

Conduct on-site infiltration tests

Subgrade Infiltration

Determining soil infiltration rates

- Dig holes on the site
- Approx. top-of-subgrade depth
- Double ring infiltrometer test
- Use lowest infiltration rate

Multiple test holes

Test area

Pollutant Removal – Figure 27

Pollutant	Infiltration Trench Design Type*			Infiltration Trenches & Porous Pavement
	0.5 in. (13 mm) of Runoff per Impervious acre	1.0 in. (25 mm) of Runoff per Impervious acre	2-year Design Storm Treatment	Median Pollutant Removal**
Total Suspended Solids	60-80	80-100	80-100	95
Total Phosphorous	40-60	40-60	60-80	70
Total Nitrogen	40-60	40-60	60-80	51
Biological Oxygen Demand	60-80	60-80	80-100	—
Bacteria	60-80	60-80	80-100	—
Metals	60-80	60-80	80-100	99 (Zn)

Design Details

Overflow and concrete edge restraints

Overflow drain

Design for the Disabled

Combine solid & permeable

Or use smaller joints

Design for Performance Monitoring

- **Observation well at lowest point**
- **Min. 6 in. (150 mm) dia. perf pipe w/cap**
- **Monitor drainage rate, sediment, water quality**
- **Cap hides under pavers**


No. 2 stone subbase
Morton Arboretum
Lisle, Illinois

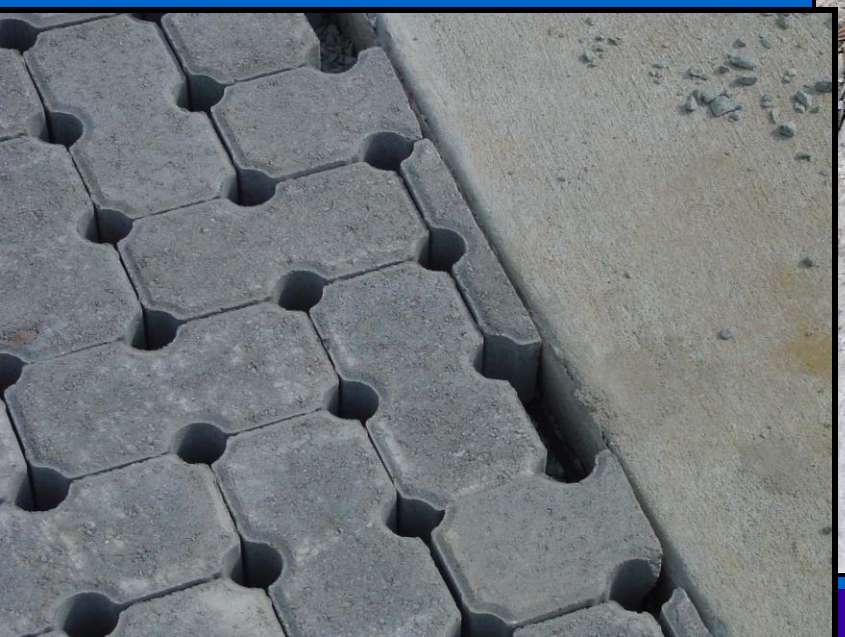

No. 57
No. 2

Construction

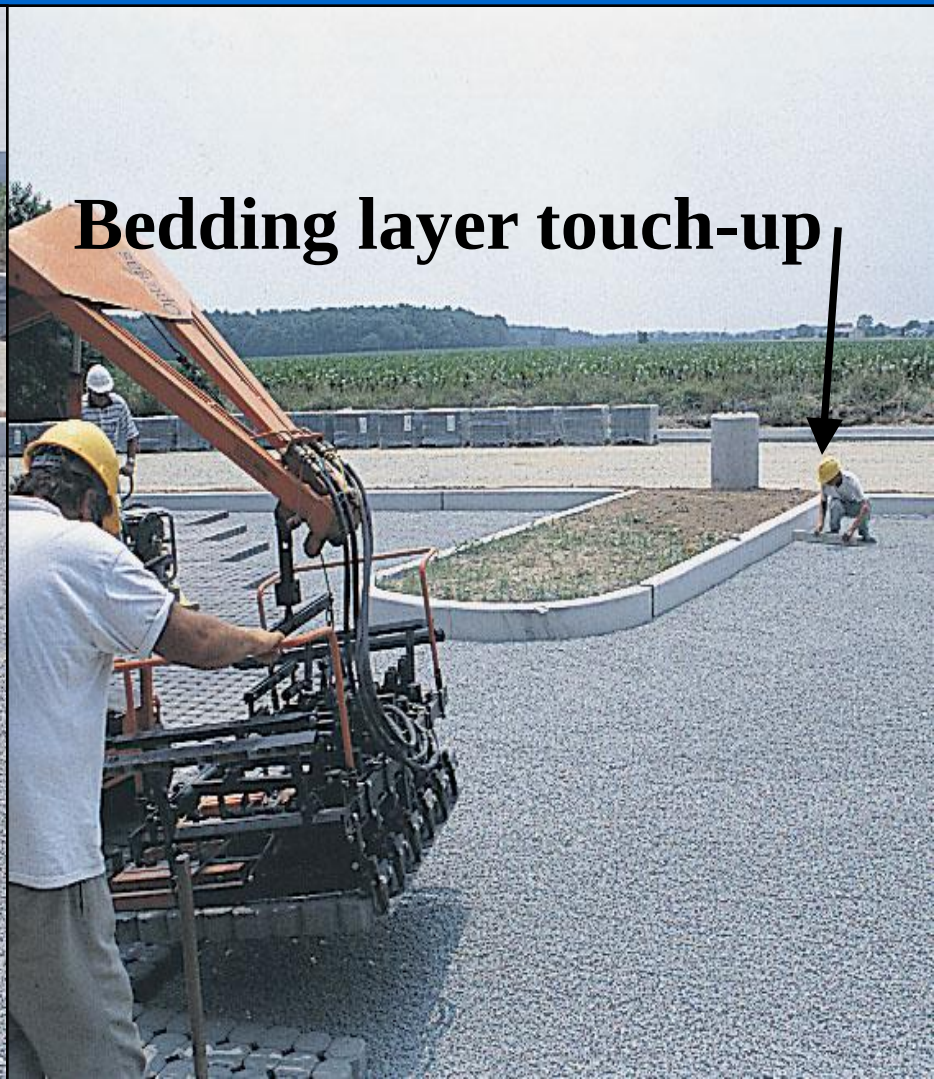
Screeding bedding layer over stone base

Construction

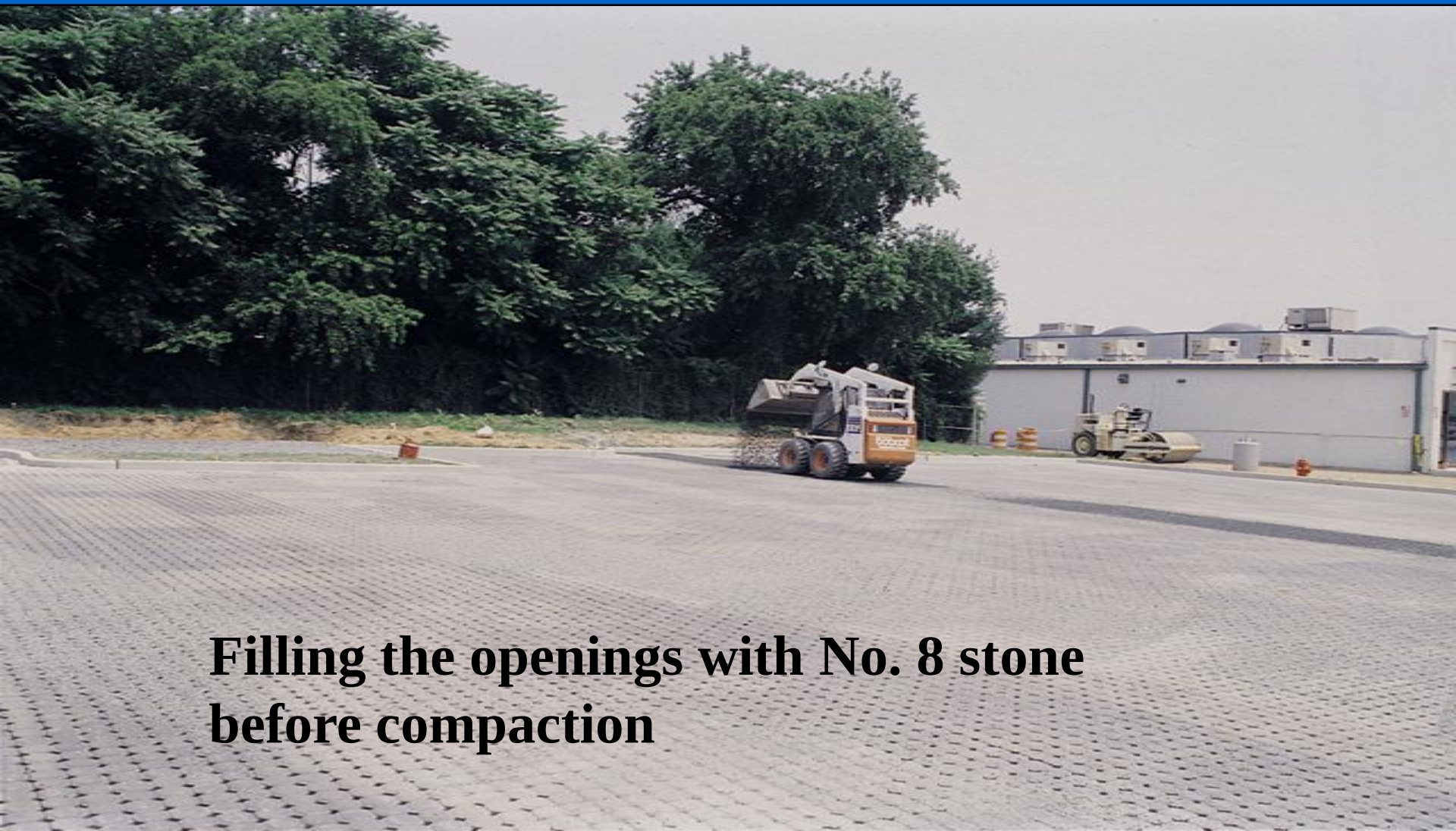
Edges cut, placed then compacted



Construction – Mechanical Installation



Construction



Filling the openings with No. 8 stone before compaction

Compaction of pavers


Excess stones removed,
then final compaction
CHEVROLET
1550

Costs

Assumptions:

31/8” thick pavers,
2 in. bedding layer
12 in. base…
15-20,000 s.f.
$7 to $10/s.f.

Does *not* include design, curbs, or pipe costs

Sustainable Design through LEED v2.2

- "Sustainable" = Development that meets the needs of the present without compromising the ability of future generations to meet their own needs
- Considers the triple-bottom-line: social, economic & environmental impacts
- LEED = Leadership in Energy & Environmental Design rating system v2.2

US Green Building Council

www.usgbc.org

LEED rating levels for project certification

Certified	26 – 32 points
Silver	33 – 38 points
Gold	39 – 51 points
Platinum	52 or greater

Types of projects:

- New construction LEED-NC
- Existing buildings
- Commercial interiors
- Building core & shell
- Homes

LEED credits offered when projects….

- **Decrease pollution through sustainable sites**
- **Increase building water use efficiency**
- **Reduce energy and atmospheric pollutants**
- **Conserve minerals and resources**
- **Improve indoor air quality**
- **Offer innovative ideas and designs**
- **Offer innovative upgrades, operations & maintenance**

Decrease runoff through Sustainable Sites

LEED Points

Credit 6.1 Stormwater design: Quantity control 1

<50% site imperviousness
Reduce to pre-development peak discharge & quantity for a 2 year, 24-hour storm

>50% site imperviousness
25% volume decrease from 2 year, 24-hour storm

Achieve both objectives with permeable interlocking concrete pavements



Decrease runoff through Sustainable Sites

	LEED Points
Credit 6.2 Stormwater design: Quality control	**1**

Capture & treat 90% of average annual Rainfall (0.5 to 1 in. depending on region)
Remove 80% of total suspended solids

Achieve 80% TSS removal with permeable Interlocking concrete pavements – proven by research

LEED Points

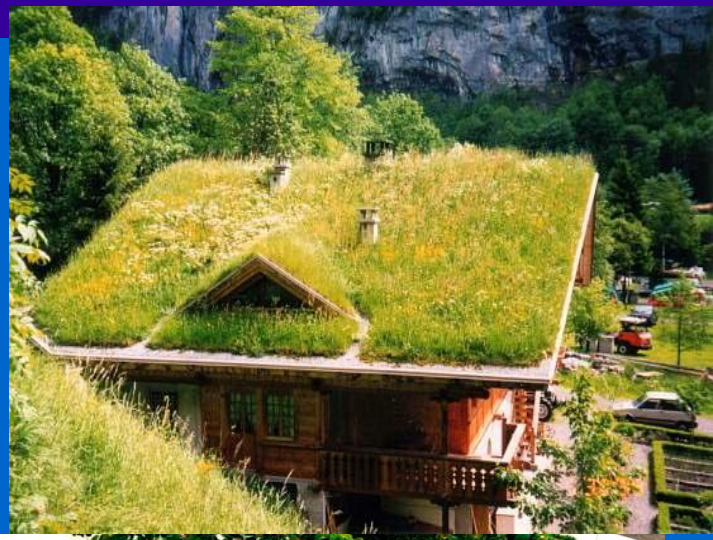
Credit 7.1 Heat Island Effect: Non-roof 1

50% of site hardscape using
Tree shade in 5 years
Paving with minimum 29 Solar Reflectance Index (SRI)
Grid pavement
OR
Place parking under roof or ground
Minimum 29 SRI on roof or deck

LEED Points

Credit 7.2 Heat Island Effect: Roof — 1

At least 75% roof with minimum 29 Solar Reflectance Index (SRI)
OR
At least 50% vegetated roof
OR
Low slope roof with min 78 SRI



Conservation of materials and resources

Credit		LEED Points
3.1	5% reused content (i.e. crushed concrete)	1
3.2	10% reused content	1
4.1	5% recycled waste content (e.g. flyash)	1
4.2	10% recycled waste content	1
5.1	20% manufactured regionally (<500 mi.)	1
5.2	50% materials extracted regionally (<500 mi.)	1

See ICPI Tech Spec 16 on LEED points from pavers

Questions?

You deserve a break.

Thank you!

www.icpi.org

icpi@icpi.org

Interlocking Concrete Pavement Institute

ICPI®