Local Aspects of Design and Construction: A Design Consultant's Perspective

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Applied Research

Pervious, Porous and Permeable Pavements

- **Pavement system designed to permit the infiltration of surface water**

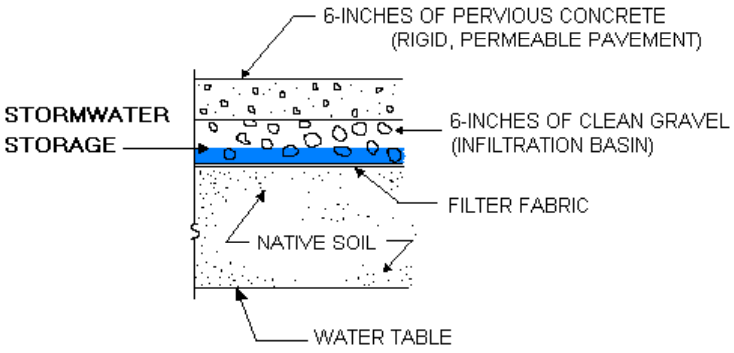
Porous Asphalt

- **Advantages**
  - Cost
  - Material & construction experience
- **Disadvantages**
  - Materials susceptible to water damage
  - Usually used for short term storage only
  - Lower relative strength

Porous Asphalt

Pervious Concrete

- **Advantages**
  - Structural strength
  - Availability of materials
- **Disadvantages**
  - Slow construction process
  - Potential material issues
  - Higher initial cost



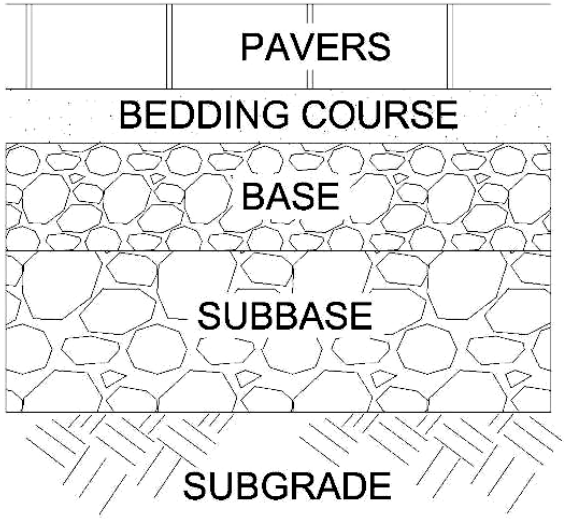
SECTION

Pervious Concrete

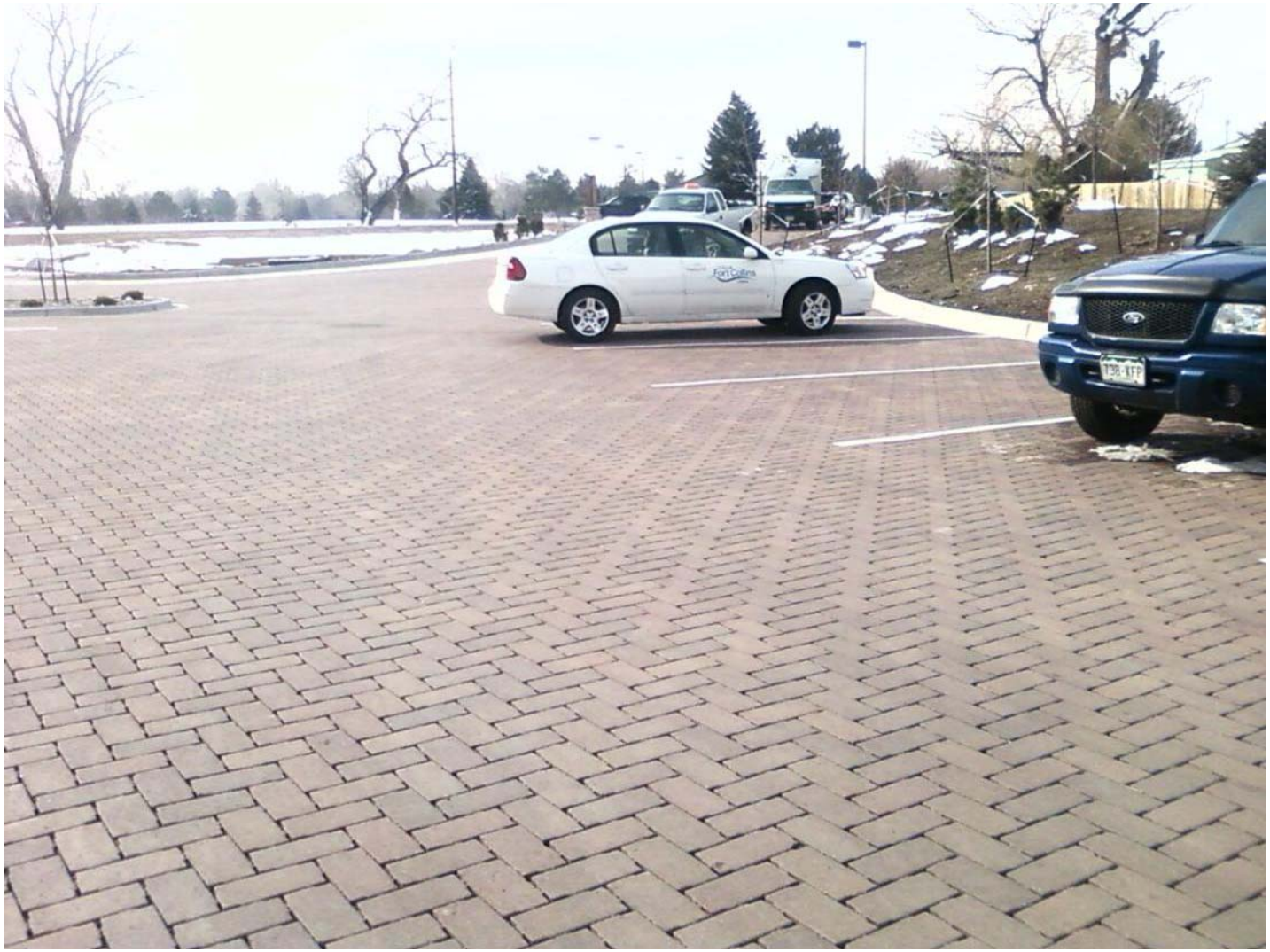
Permeable Interlocking Concrete Pavers

- **Advantages**
  - Ease of construction
  - High surface infiltration options
  - Aesthetics
  - Ease of maintenance and repair

- **Disadvantages**
  - Typically higher cost
  - Limited to lower speed roadways

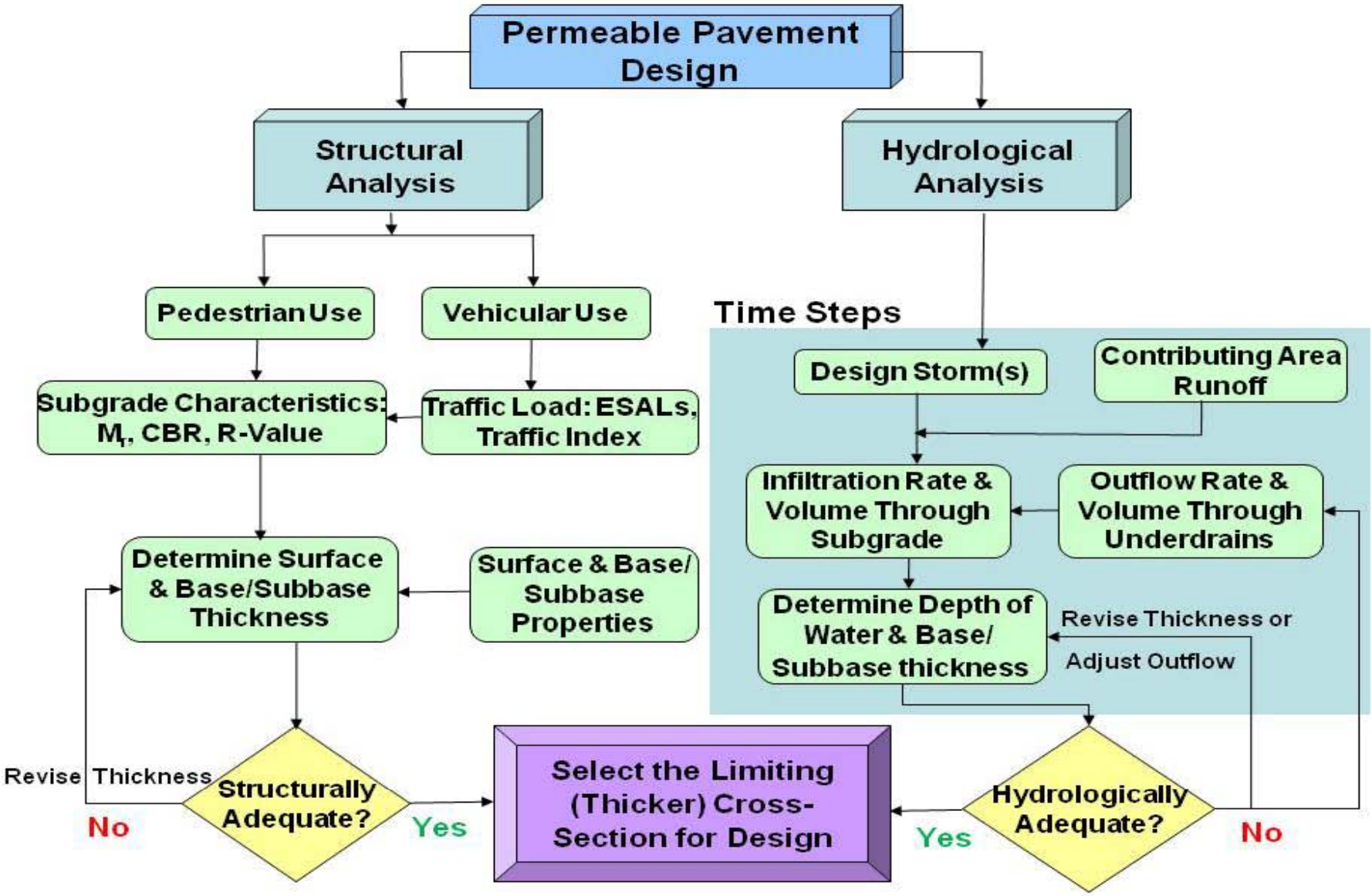


Permeable Interlocking Concrete Pavers



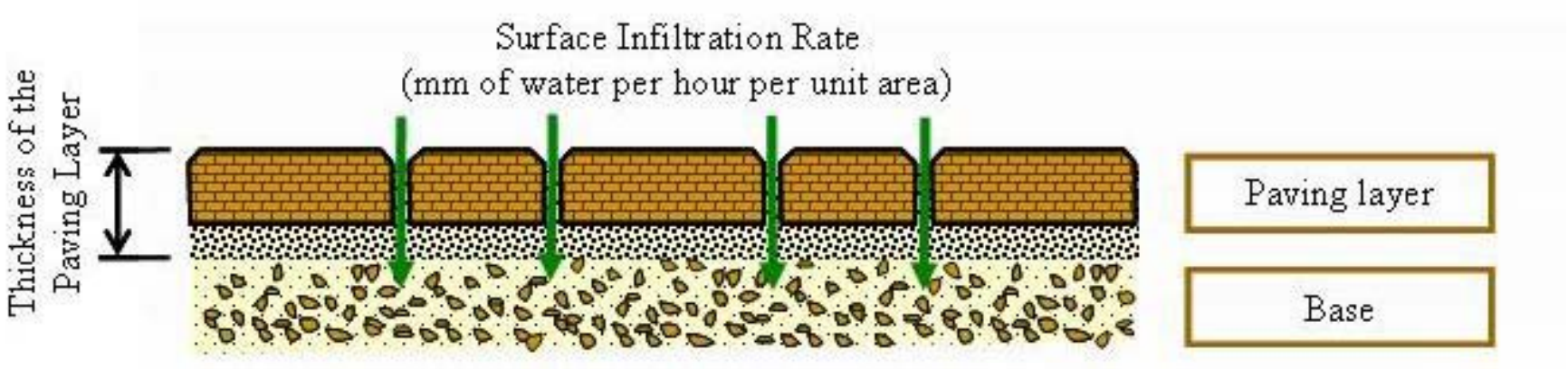
Typical Application

Pavement Design Process

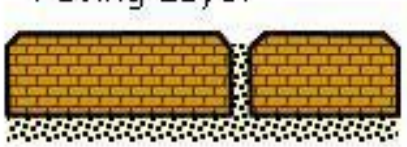


Paving Layer Design Considerations

Infiltration



Structural Capacity

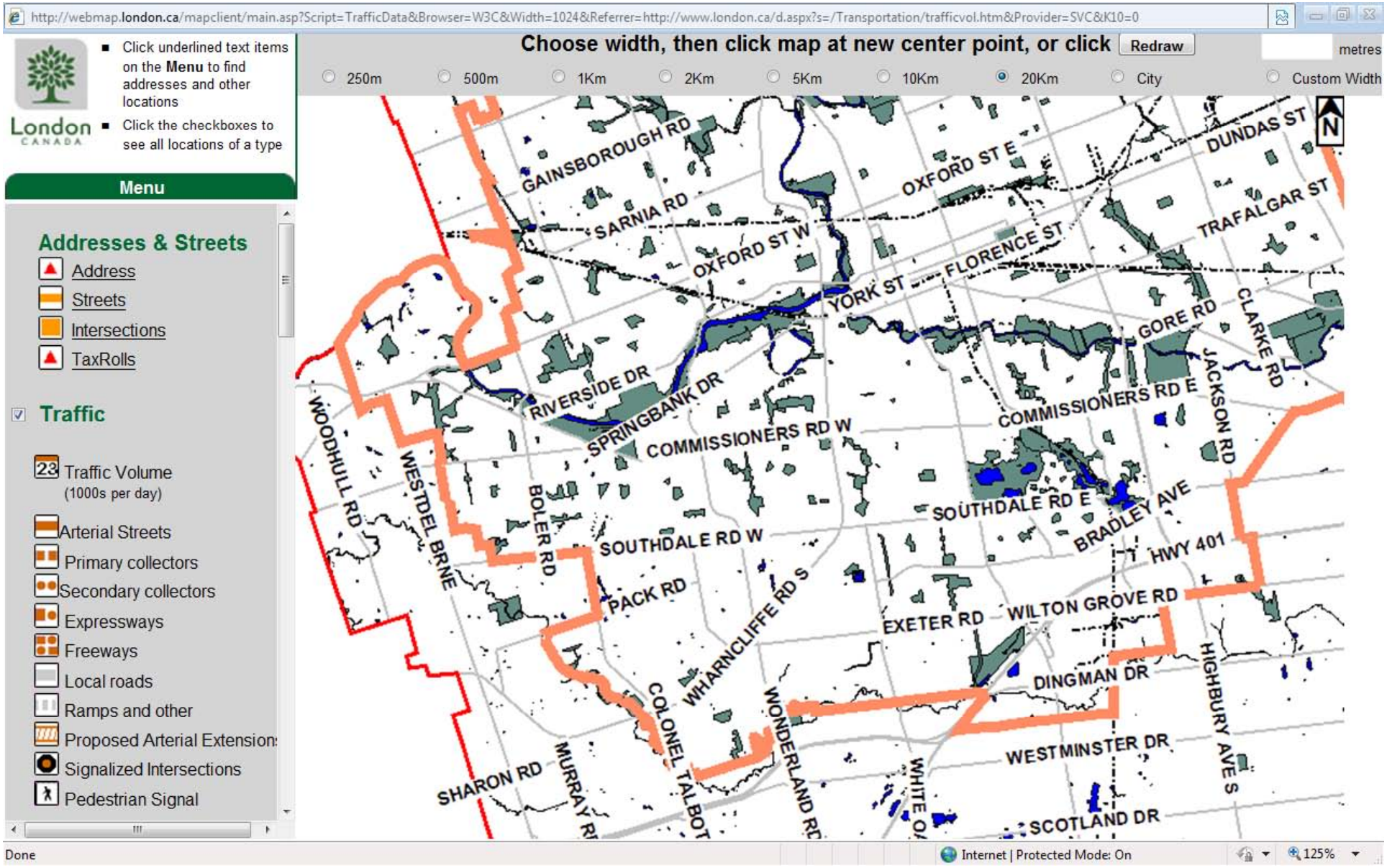


Paving Layer	Thickness		Structural Layer Coefficient		Structural Number
	130 mm	X	0.30	=	**39 mm**
	5 1/8 in	X	0.30	=	**1.54 in**

Traffic Data

- **Traffic data is required for structural design**
- **Several choices**
  - **Best** (actual traffic counts, including type and frequency of heavy vehicles)
  - **Fair** (estimate based on type of facility, i.e. recreational parking area, semi-industrial, roadway, etc.)
  - **Poor** (guess)

Sources of Traffic Data

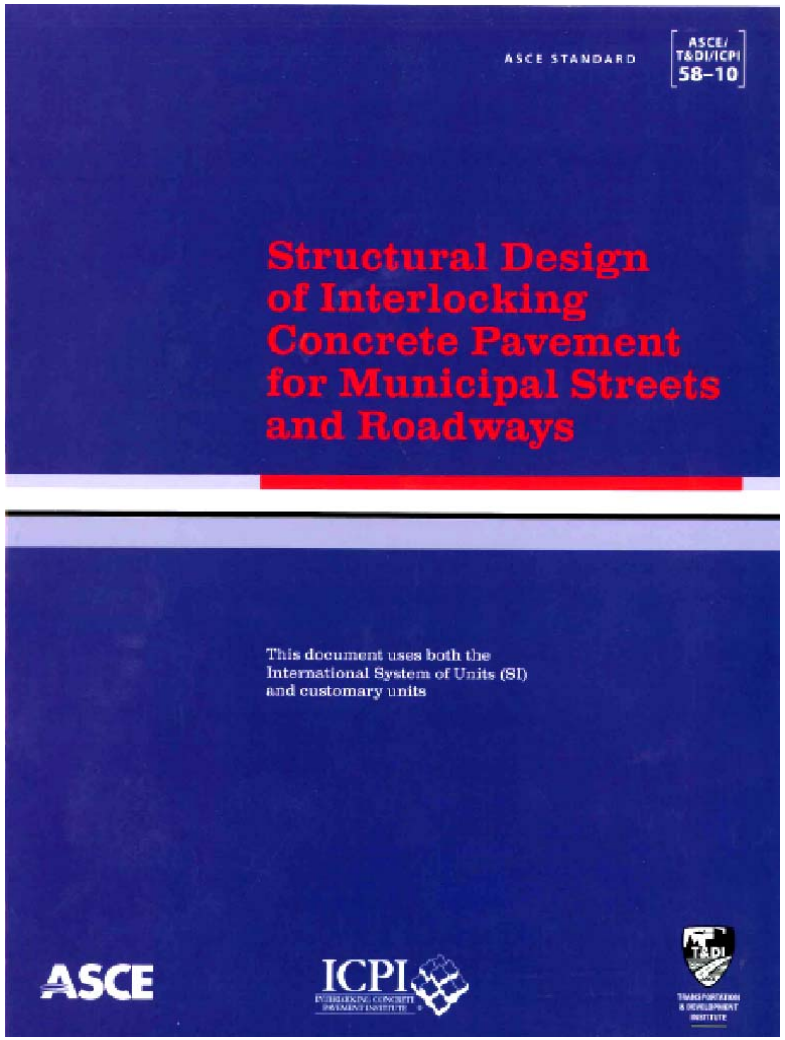


Subgrade Type and Quality

- **Subgrade support is one of the most important parameters governing pavement structural design**
  - **Best** (complete resilient modulus testing from in-situ materials to determine input values)
  - **Fair** (estimate resilient modulus based on other site or subgrade materials testing, i.e. FWD back-calculation, dynamic cone penetrometer, California Bearing Ratio)
  - **Poor** (select based on 'typical' subgrade type and drainage ability

Subgrade Type and Quality

- **Possible Source – ASCE 58-10 Publication**



ASCE
$65 list
$48.75 ASCE member
www.asce.org/
Product.aspx?id=2147489021

ICPI
$65 list
$40 ICPI member
www.icpi.org/online-store

Plus shipping & handling

Recommended M_R Values

Brief Description	Category No.	Classification	Drainage Characteristics	Susceptibility to Frost Action	Resilient Modulus (M_R) for Typical Subgrade Conditions, MPa		
					Good	Fair	Poor
Rock, rock fill, shattered rock, boulders/cobbles	1	Boulders/ cobbles	Excellent	None	90	80	70
Well graded gravels and sands suitable as granular borrow	2	GW, SW	Excellent	Negligible	80	70	50
Poorly graded gravels and sands	3	GP, SP	Excellent to fair	Negligible to slight	70	50	35
Silty gravels and sands	4	GM, SM	Fair to semi-impervious	Slight to moderate	50	35	30
Clayey gravels and sands	5	GC, SC	Practically impervious	Negligible to slight	40	30	25
Silts and sandy silts	6	ML, MI	Typically poor	Severe	30	25	18
Low plasticity clays and compressible silts	7	CL, MH	Practically impervious	Slight to severe	27	20	15
Medium to high plasticity clays	8	CI; CH	Semi-impervious to impervious	Negligible to severe	25	20	15

Subgrade Infiltration Design Rate

Designation: D 3385 – 03

Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer[1]

This standard is issued under the fixed designation D 3385; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method describes a procedure for field measurement of the rate of infiltration of liquid (typically water) into soils using double-ring infiltrometer.

1.2 Soils should be regarded as natural occurring fine or coarse-grained soils or processed materials or mixtures of natural soils and processed materials, or other porous materials, and which are basically insoluble and are in accordance with requirements of 1.5.

1.3 This test method is particularly applicable to relatively uniform fine-grained soils, with an absence of very plastic (fat) clays and gravel-size particles and with moderate to low resistance to ring penetration.

1.4 This test method may be conducted at the ground surface or at given depths in pits, and on bare soil or with vegetation in place, depending on the conditions for which infiltration rates are desired. However, this test method cannot be conducted where the test surface is below the ground water table or perched water table.

1.5 This test method is difficult to use or the resultant data may be unreliable, or both, in very pervious or impervious soils (soils with a hydraulic conductivity greater than about 10^{-2} cm/s or less than about 1×10^{-6} cm/s) or in dry or stiff soils that most likely will fracture when the rings are installed. For soils with hydraulic conductivity less than 1×10^{-6} cm/s refer to Test Method D 5093.

1.6 This test method cannot be used directly to determine the hydraulic conductivity (coefficient of permeability) of the soil (see 5.2).

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 5093 Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer With a Sealed Inner Ring[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *incremental infiltration velocity*—the quantity of flow per unit area over an increment of time. It has the same units as the infiltration rate.

3.1.2 *infiltration*—the downward entry of liquid into the soil.

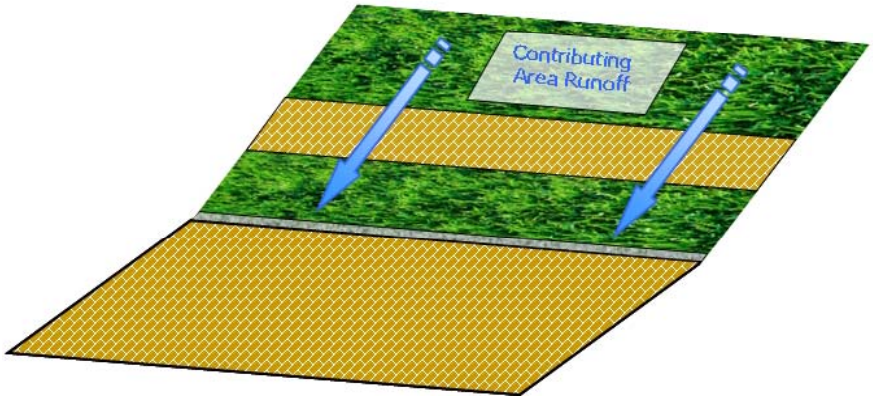
3.1.3 *infiltration rate*—a selected rate, based on measured incremental infiltration velocities, at which liquid can enter the soil under specified conditions, including the presence of an excess of liquid. It has the dimensions of velocity (that is, $cm^3 cm^{-2} h^{-1} = cm\ h^{-1}$).

3.1.4 *infiltrometer*—a device for measuring the rate of entry of liquid into a porous body, for example, water into soil.

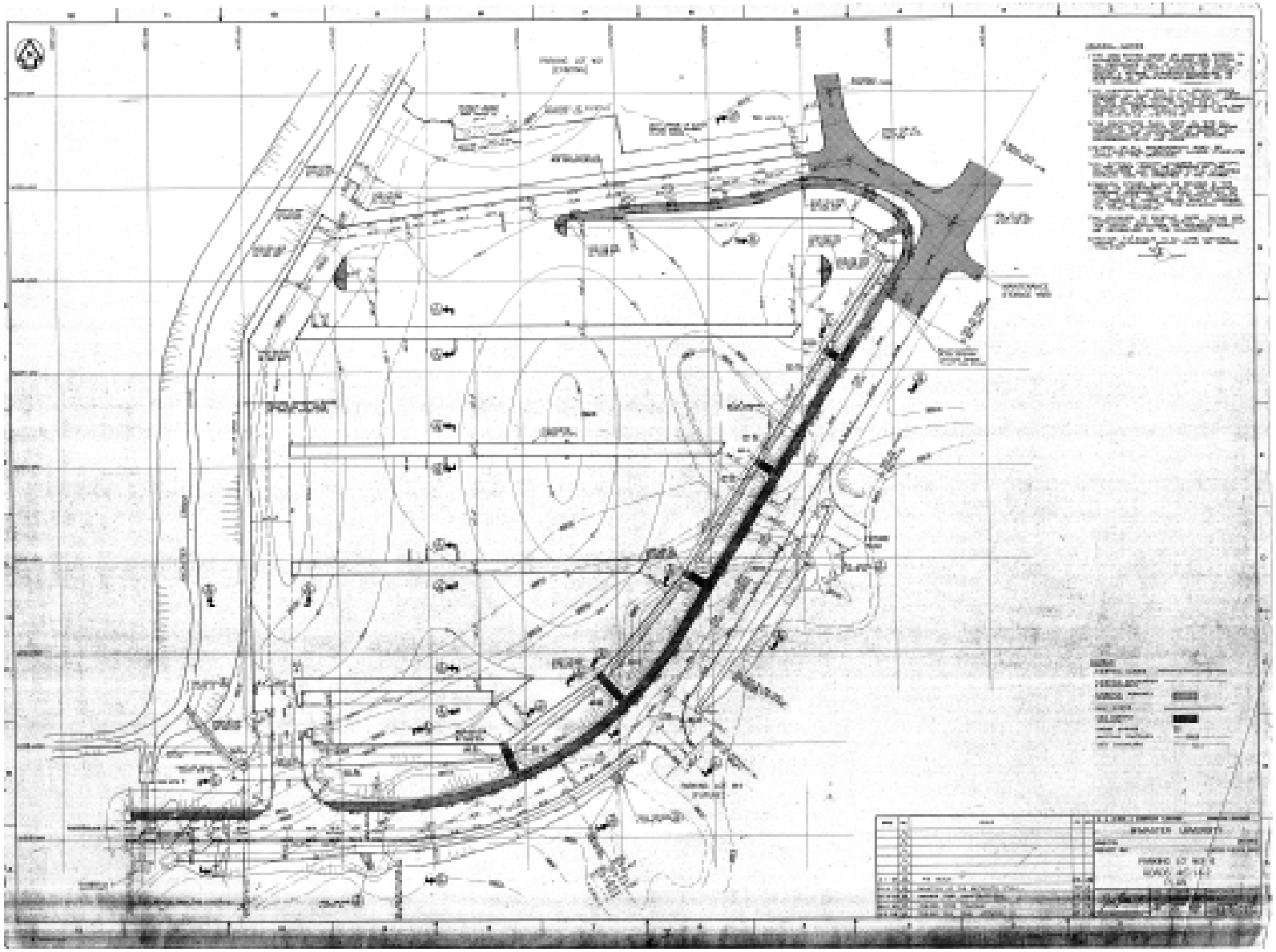
Infiltration Test Apparatus

Source of Water - Rainfall

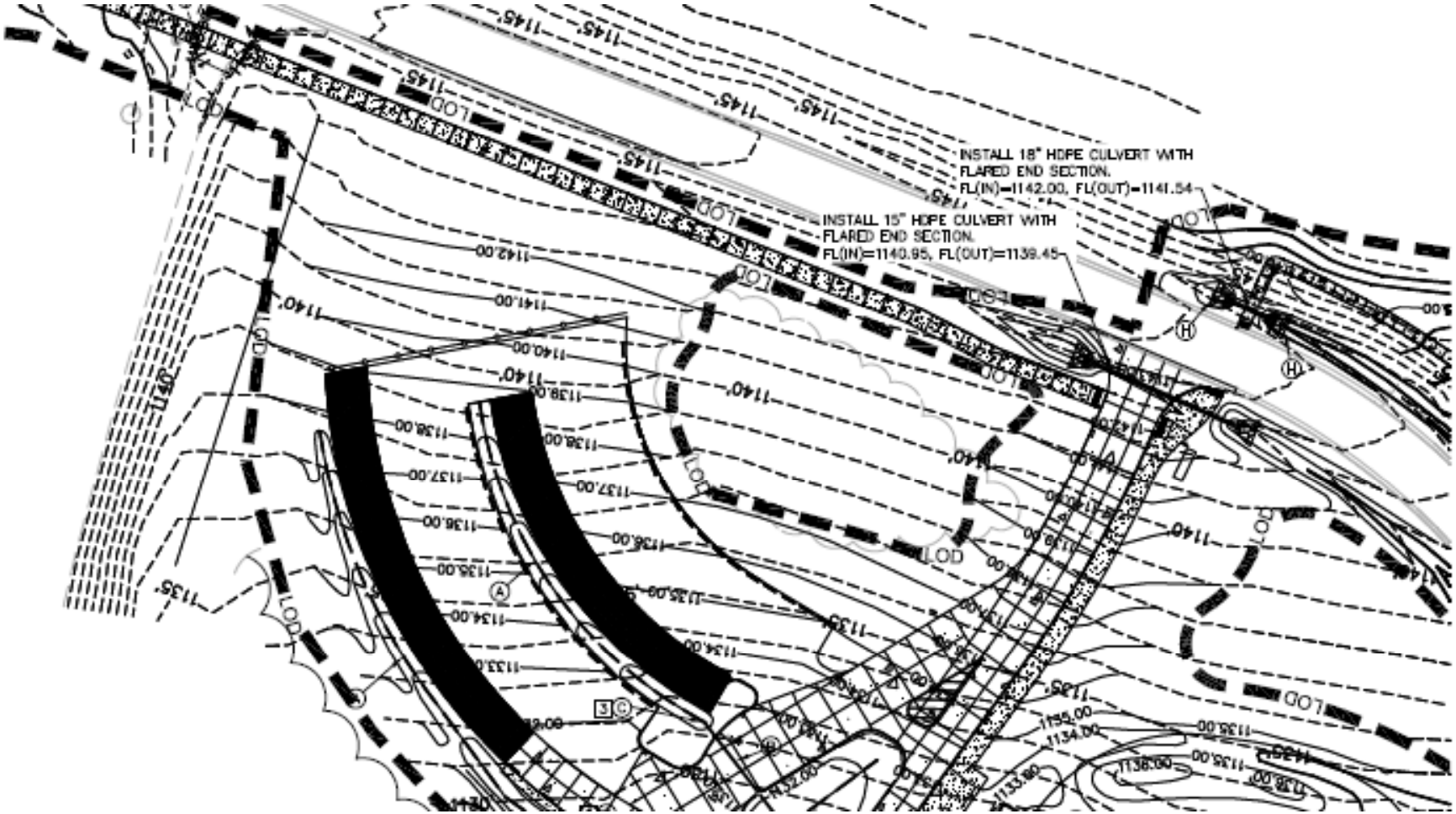
Source of Water - Contributing Area



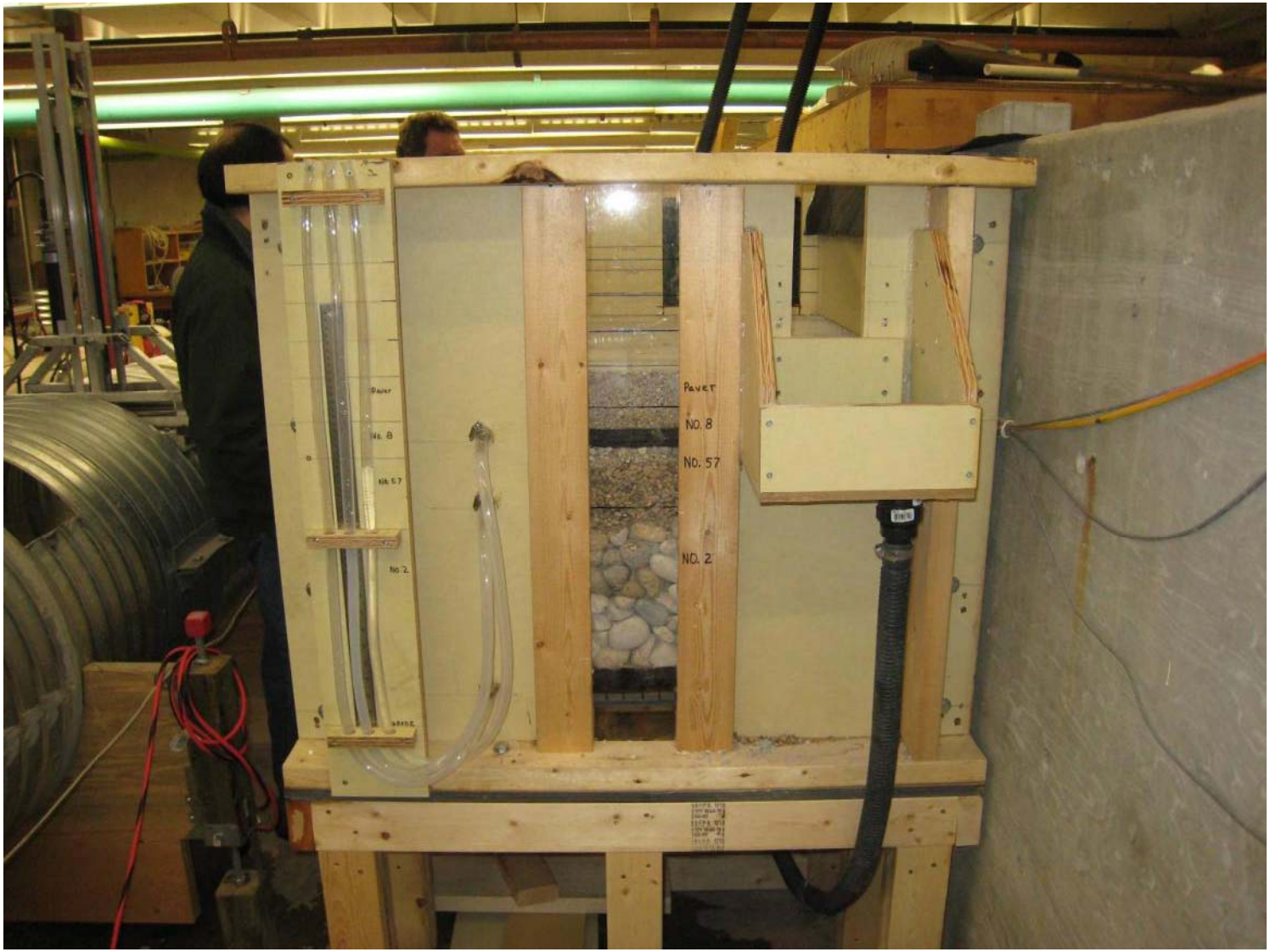
Site Plans – Evaluate Drainage



Site Plans – Evaluate Drainage

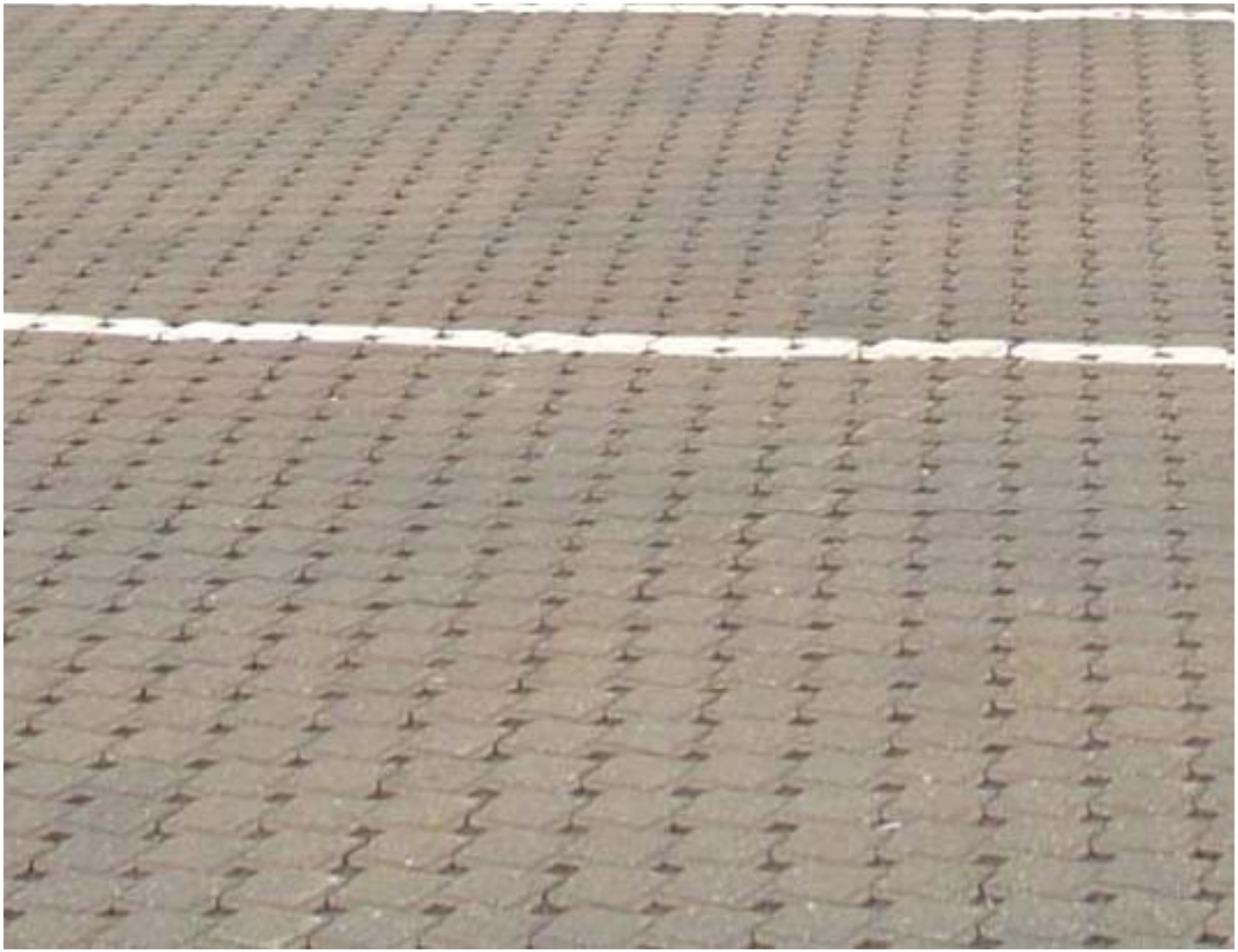


Permeability of the Surface



Permeability of the Surface

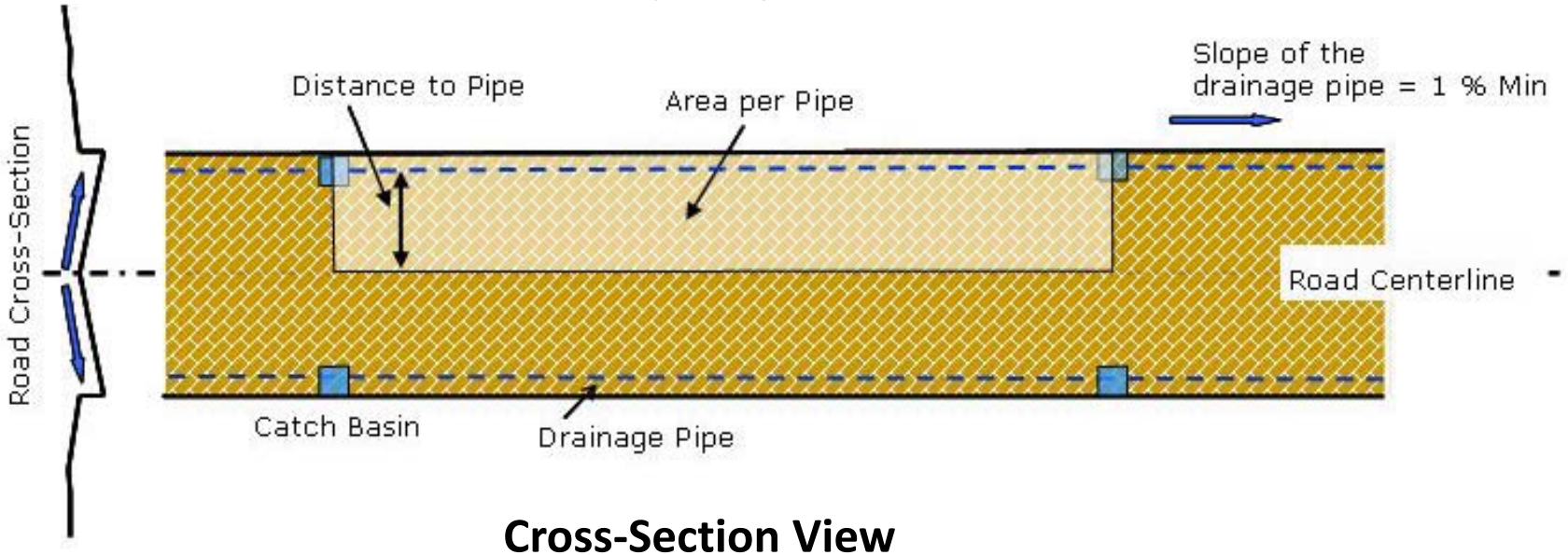
Drainage Gap Design



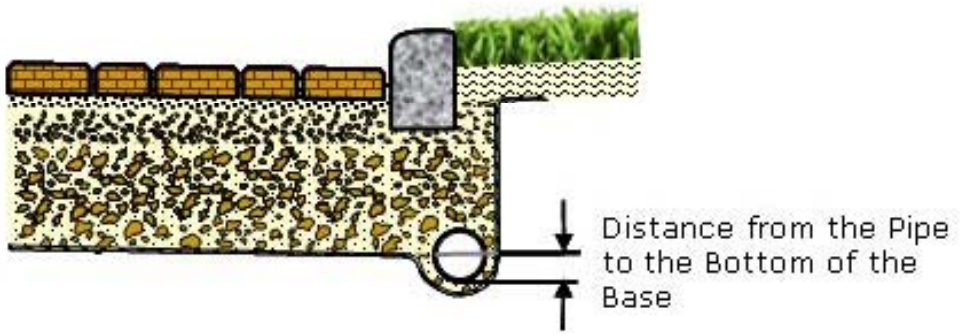
Supplementary Surface Drainage

Pipe Subdrain System

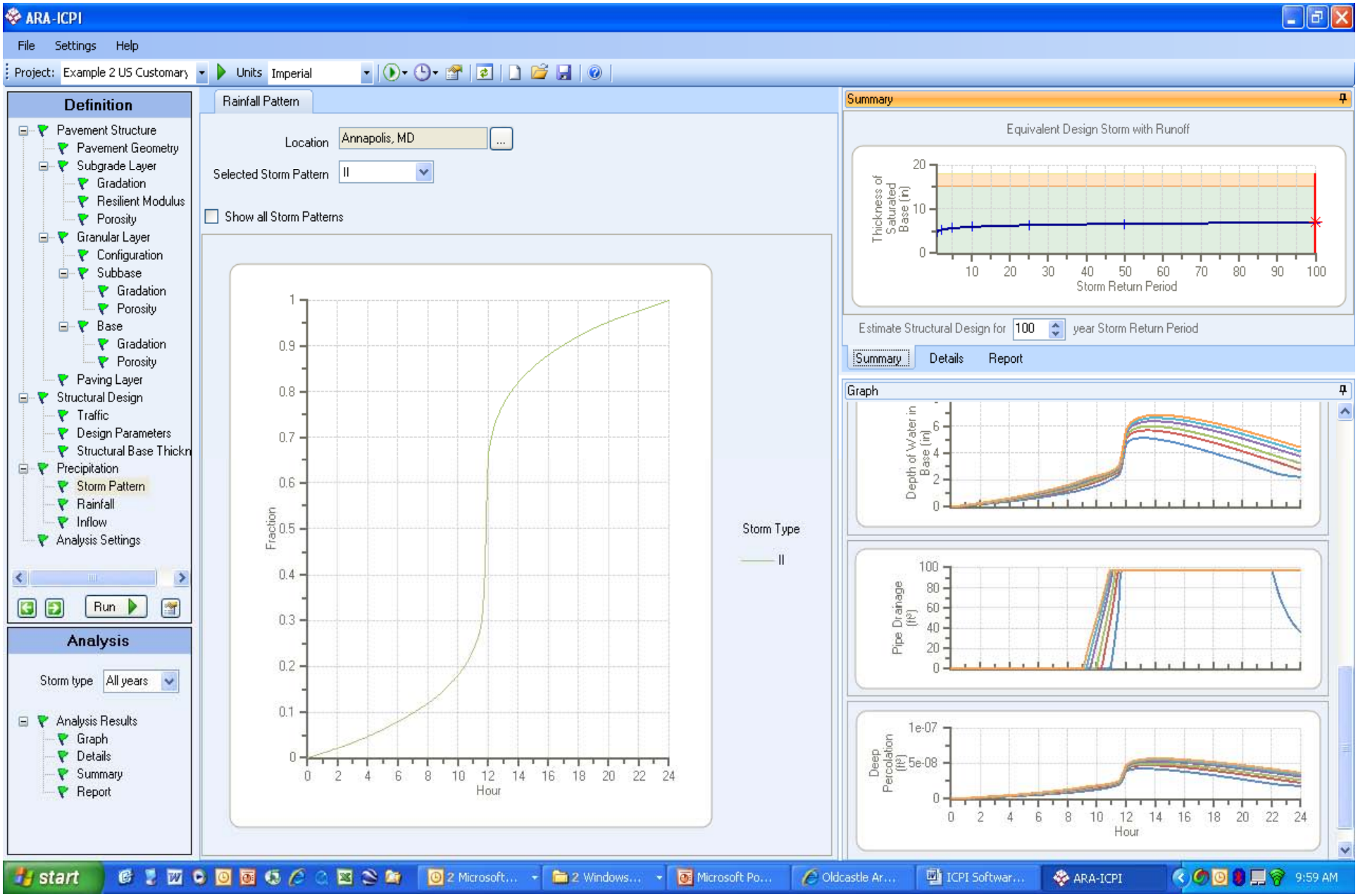
Plan View



Cross-Section View



Permeable Design Pro Analysis



Construction and Maintenance

Site Preparation and Grading

Base Materials

- **Availability**
  - **Local DOT aggregate specifications**
  - **ICPI recommendations**
  - **Local aggregate sources**
- **Compaction**
  - **No standard Proctor density**
  - **Establish target density**
  - **Roller versus plate compactor (parking lot/driveway)**
  - **Lift thickness**
- **Angularity and hardness**

Aggregates

Designation: D 448 – 03a

Standard Classification for Sizes of Aggregate for Road and Bridge Construction[1]

This standard is issued under the fixed designation D 448; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This classification defines aggregate size designations and ranges in mechanical analyses for standard sizes of coarse aggregate and screenings for use in the construction and maintenance of various types of highways and bridges.

1.2 With regard to sieve sizes and the size of aggregate as determined by the use of testing sieves, the values in inch-pound units are shown for the convenience of the user; however, the standard sieve designation shown in parentheses is the standard value as stated in Specification E 11.

1.3 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

D 75 Practice for Sampling Aggregates

E 11 Specification for Wire Cloth and Sieves for Testing Purposes

3. Significance and Use

3.1 Some contract documents specify certain aggregate sizes for specific uses or may suggest one or more of these sizes as appropriate for the preparation of various end-product mixtures. In some cases, closer limits on variability of the aggregate grading are required.

4. Manufacture

4.1 The standard sizes of aggregate described in this classification are manufactured by means of any suitable process used to separate raw material into the desired size ranges. Production of standard sizes by blending two or more different components is permitted.

5. Standard Sizes

5.1 Standard sizes of coarse aggregate shall comply with the sizes given in Table 1. All sizes shall be determined by means of laboratory sieves having square openings and conforming to Specification E 11.

Aggregates

TABLE 1 Standard Sizes of Processed Aggregate

Size Number	Nominal Size, Square Openings	Amounts Finer than Each Laboratory Sieve (Square Openings), mass percent														
		100-mm (4-in.)	90-mm (3½-in.)	75-mm (3-in.)	63-mm (2½-in.)	50-mm (2-in.)	37.5-mm (1½-in.)	25.0-mm (1-in.)	19.0-mm (¾-in.)	12.5-mm (½-in.)	9.5-mm (⅜-in.)	4.75-mm (No. 4)	2.36-mm (No. 8)	1.18-mm (No. 16)	300-µm (No. 50)	150-µm (No. 100)
1	90 to 37.5-mm (3½ to 1½-in.)	100	90 to 100	...	25 to 60	...	0 to 15	...	0 to 5	...	...	...	...	...	...	...
2	63 to 37.5-mm (2½ to 1½-in.)	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...	...	...
24	63 to 19.0-mm (2½ to ¾-in.)	...	...	100	90 to 100	...	25 to 60	...	0 to 10	0 to 5	...	...	...	...	...	...
3	50 to 25.0-mm (2 to 1-in.)	...	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...	...
357	50 to 4.75-mm (2-in. to No. 4)	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	...	0 to 5	...	...	...	...
4	37.5 to 19.0-mm (1½ to ¾-in.)	...	...	...	...	100	90 to 100	20 to 55	0 to 15	...	0 to 5	...	...	...	...	...
467	37.5 to 4.75-mm (1½-in. to No. 4)	...	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	0 to 5	...	...	...	...
5	25.0 to 12.5-mm. (1 to ½-in.)	...	...	...	...	...	100	90 to 100	20 to 55	0 to 10	0 to 5	...	...	...	...	...
56	25.0 to 9.5-mm (1 to ⅜-in.)	...	...	...	...	...	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	...	...	...	...
57	25.0 to 4.75-mm (1-in. to No. 4)	...	...	...	...	...	100	95 to 100	...	25 to 60	...	0 to 10	0 to 5	...	...	...
6	19.0 to 9.5-mm (¾ to ⅜-in.)	...	...	...	...	...	...	100	90 to 100	20 to 55	0 to 15	0 to 5	...	...	...	...
67	19.0 to 4.75-mm (¾-in. to No. 4)	...	...	...	...	...	...	100	90 to 100	...	20 to 55	0 to 10	0 to 5	...	...	...
68	19.0 to 2.36-mm (¾-in. to No. 8)	...	...	...	...	...	...	100	90 to 100	...	30 to 65	5 to 25	0 to 10	0 to 5	...	...
7	12.5 to 4.75-mm (½-in. to No. 4)	...	...	...	...	...	...	...	100	90 to 100	40 to 70	0 to 15	0 to 5	...	...	...
78	12.5 to 2.36-mm (½-in. to No. 8)	...	...	...	...	...	...	...	100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5	...	...
8	9.5 to 2.36-mm (⅜-in. to No. 8)	...	...	...	...	...	...	...	...	100	85 to 100	10 to 30	0 to 10	0 to 5	...	...
89	9.5 to 1.18-mm (⅜-in. to No. 16)	...	...	...	...	...	...	...	...	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5	...
9	4.75 to 1.18-mm (No. 4 to No. 16)	...	...	...	...	...	...	...	...	...	100	85 to 100	10 to 40	0 to 10	0 to 5	...
10	4.75-mm (No. 4 to 0[A])	...	...	...	...	...	...	...	...	...	100	85 to 100	...	...	...	10 to 30

[A] Screenings.

Base and Subbase Materials

ONTARIO PROVINCIAL STANDARD SPECIFICATION

METRIC
OPSS 1010
November 2003

MATERIAL SPECIFICATION FOR AGGREGATES - BASE, SUBBASE, SELECT SUBGRADE, AND BACKFILL MATERIAL

TABLE OF CONTENTS

Base and Subbase Materials

Physical Property Requirements

Laboratory Test	MTO Test Number	Granular O	Granular A	Granular S	Granular B Type I and Type II	Granular M	Select Subgrade Material
Coarse Aggregate Petrographic Requirement	LS-609	(Note 2)	Note 1) Note 2)	(Note 2)	(Note 1) (Note 2)	(Note 1) (Note 2)	(Note 2)
Freeze-Thaw Loss, % maximum	LS-614	15	N/A	N/A	N/A	N/A	N/A
Fine Aggregate Petrographic Requirement	LS-616 LS-709		Note 3)				
Micro-Deval Abrasion Coarse Aggregate loss, % maximum	LS-618	21	25	25	30 (Note 4)	25	30 (Note 4)
Micro-Deval Abrasion Fine Aggregate loss, % maximum	LS-619	25	30	30	35	30	N/A
Plasticity Index	LS-704	0	0	0	0	0	0
Percent crushed, minimum	LS-607	100	50	50	N/A	50	N/A
2 or more crushed faces, % minimum	LS-617	85	N/A	N/A	N/A	N/A	N/A
Asphalt Coated Particles, % maximum	LS-621	N/A	30	30	(Note 5)	30	N/A

Base and Subbase Materials

Gradation Requirements - Percent Passing

MTO Test Number	Sieve	Granular						Select Subgrade Material
		O	A	S	B (Note 1)		M	
					Type 1 (Note 2)	Type II		
LS-602	150 mm	N/A	N/A	N/A	100	N/A	N/A	100
	106 mm	N/A	N/A	N/A	N/A	100	N/A	N/A
	37.5 mm	100	N/A	N/A	N/A	N/A	N/A	N/A
	26.5 mm	95-100	100	100	50-100	50-100	N/A	50-100
	19.0 mm	80-95	85-100 (87-100*)	90-100	N/A	N/A	100	N/A
	13.2 mm	60-80	65-90 (75-95*)	75-100	N/A	N/A	75-95	N/A
	9.5 mm	50-70	50-73 (60-83*)	60-85	N/A	N/A	55-80	N/A
	4.75 mm	20-45	35-55 (40-60*)	40-60	20-100	20-55	35-55	20-100
	1.18 mm	0-15	15-40	20-40	10-100	10-40	15-40	10-100
	300 µm	N/A	5-22	11-25	2-65	5-22	5-22	5-95
	150 µm	N/A	N/A	N/A	N/A	N/A	N/A	2.0-65.0
	75 µm	0-10	2.0-8.0 (2.0-10.0**)	9.0-15.0 (9.0-17.0**)	0-8.0 (0-10.0**)	0-10.0	2.0-8.0 (2.0-10.0**)	0-25.0

Do not want any fines

Base and Subbase Materials

MATERIAL SPECIFICATION FOR HOT MIX ASPHALT

TABLE OF CONTENTS

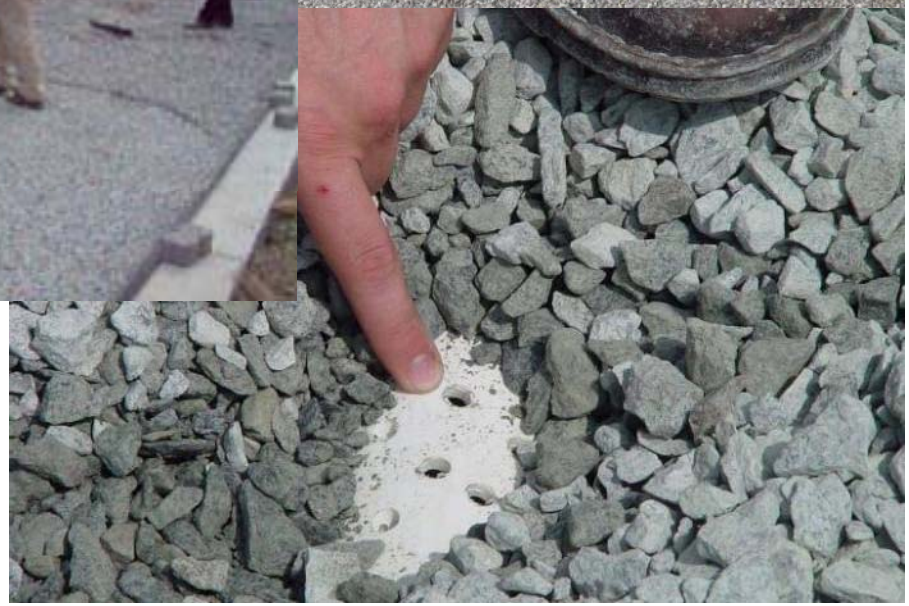
Base and Subbase Materials

Gradation Requirements - Mix Design Criteria

Mix Types	Percentage Passing by Dry Mass of Aggregates											
	Sieves											
	mm								µm			
	26.5	19.0	16.0	13.2	9.5	4.75	2.36	1.18	600	300	150	75
DFC and HL 1			100	98-100	75-90	(Note 1)	36-64	25-58	16-45	7-26	3-10	0.5
HL 2					100	85-100	70-90	50-75	30-55	15-55	5-16	3-8
HL 3 and HL 3HS			100	98-100	75-90	50-60	36-60	25-58	16-45	7-26	3-10	0-5
HL 3F			100	98-100	85-94	65-75	52-75	36-72	23-56	10-32	3-12	0-6
HL 4		100	98-100	83-95	62-82	45-60	27-60	16-60	8-47	4-27	1-10	0-6
HL 4F		100	98-100	90-98	80-92	65-80	52-80	36-72	21-56	10-32	3-12	0-6
HL 8 and MDBC	100	94-100	77-95	65-90	48-78	30-50	21-50	12-49	6-38	3-22	1-9	0-6
HDBC	100	94-100	77-95	65-90	48-78	(Note 2)	21-54	12-49	6-38	3-22	1-9	0-6

Coarse portion of aggregate gradation only, i.e. zero percent passing 4.75 mm sieve size

Subbase & Base Preparation

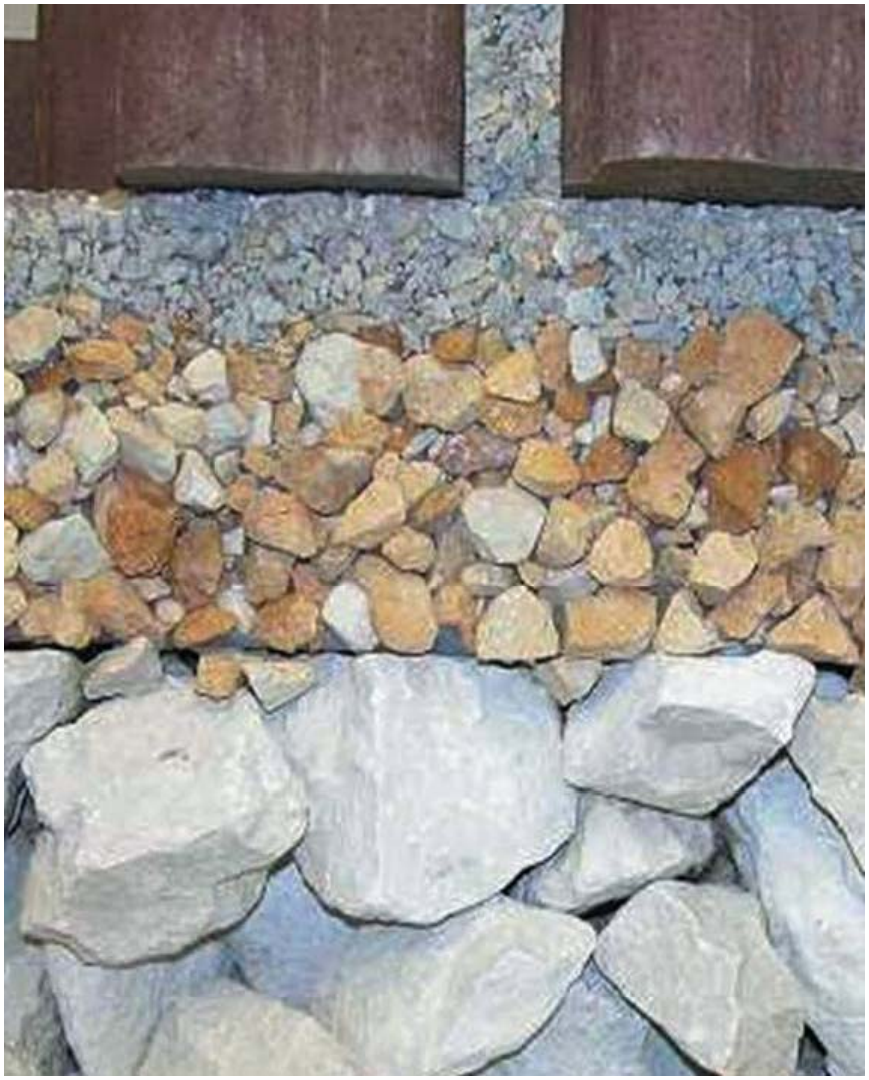



HAMM

Base/Subbase Compaction

- **Compaction Specification**
  - **Test strip**
  - **Target density using Nuclear Density Gauge (backscatter mode)**
  - **10 ton vibratory roller, 13,500 lbf plate compactor**
  - **2 passes, 5 backscatter tests (average = target density)**
  - **2 more passes, 3 backscatter tests – if > 1.2 pcf then two more passes (repeat until difference lower)**
  - **Take 7 more tests, average = target density to achieve**

Aggregate Materials



Paver Installation

Mechanical installation reduces construction time

No curing – immediate availability to traffic

Can be reinstated after repairs

Guide construction specs at www.icpi.org

Joint Aggregate Installation

Porous Asphalt Installation

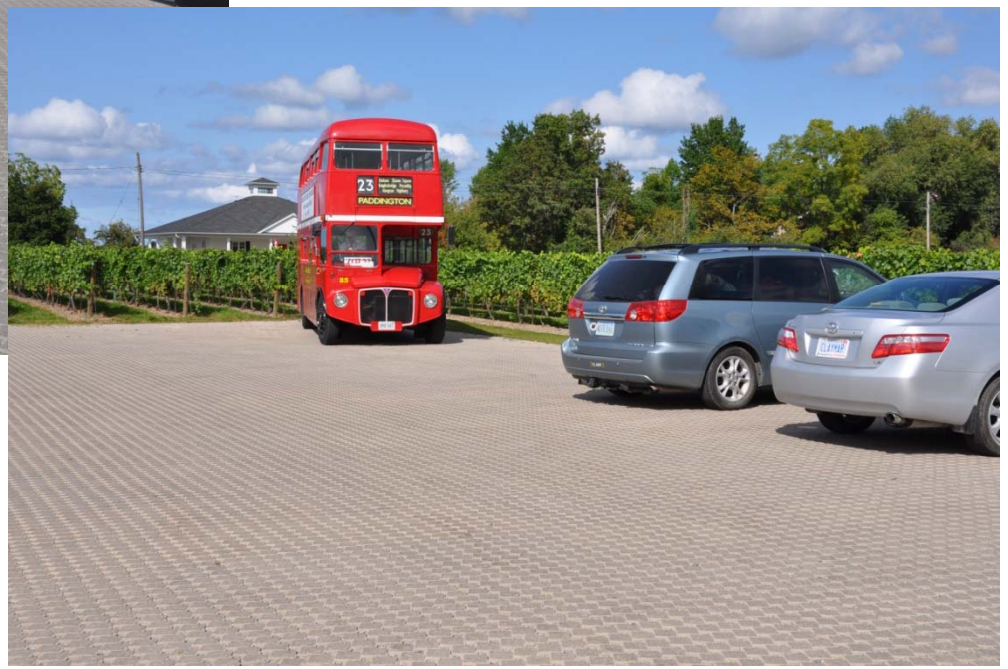
Pervious Concrete Installation

Maintenance

- ***Annually*: inspection of observation well after major storm, vacuum and sweep surface – improves infiltration**
- **Maintenance checklist**
- **Model maintenance agreement**

Maintenance

Ontario Examples

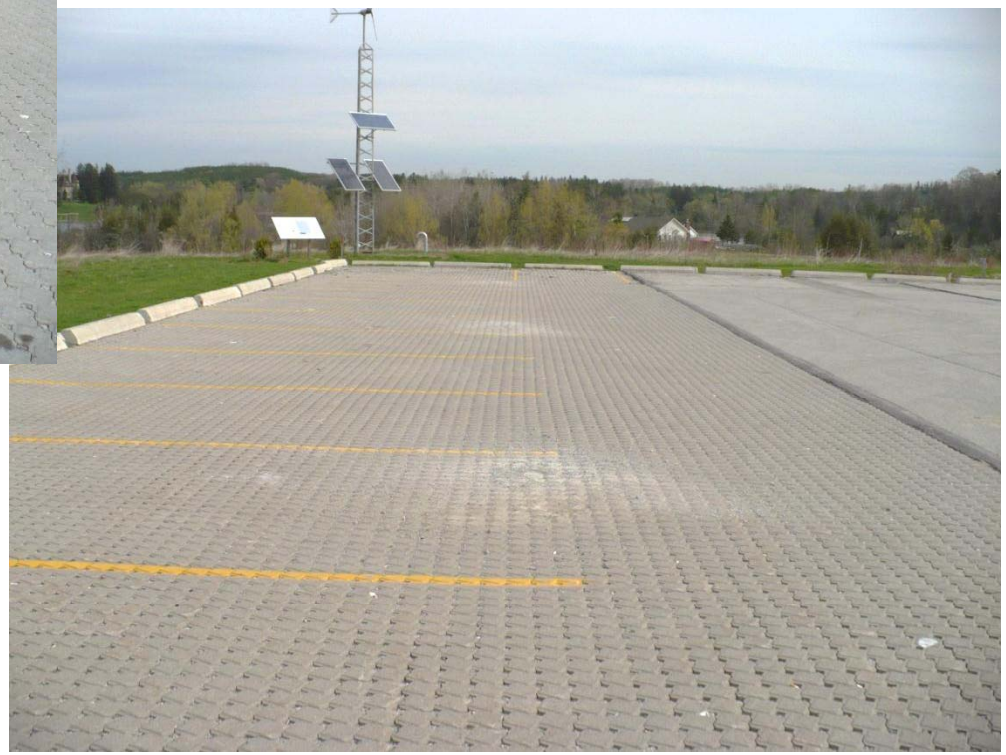


Inniskillin Winery, Niagara-on-the-Lake

Ontario Examples

Toronto Waterfront

Ontario Examples



Seneca College, King City, Ontario

Ontario Examples

Brampton Veterinary Hospital

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