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Geotextile Separation to Prevent Migration of Subgrade Fines

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Basic Definitions:

- Pavements = Bound Layers + Unbound Base + Subgrade
- Subbase = Unbound Coarse Aggregate
- Subgrade = Soil (Native Material)

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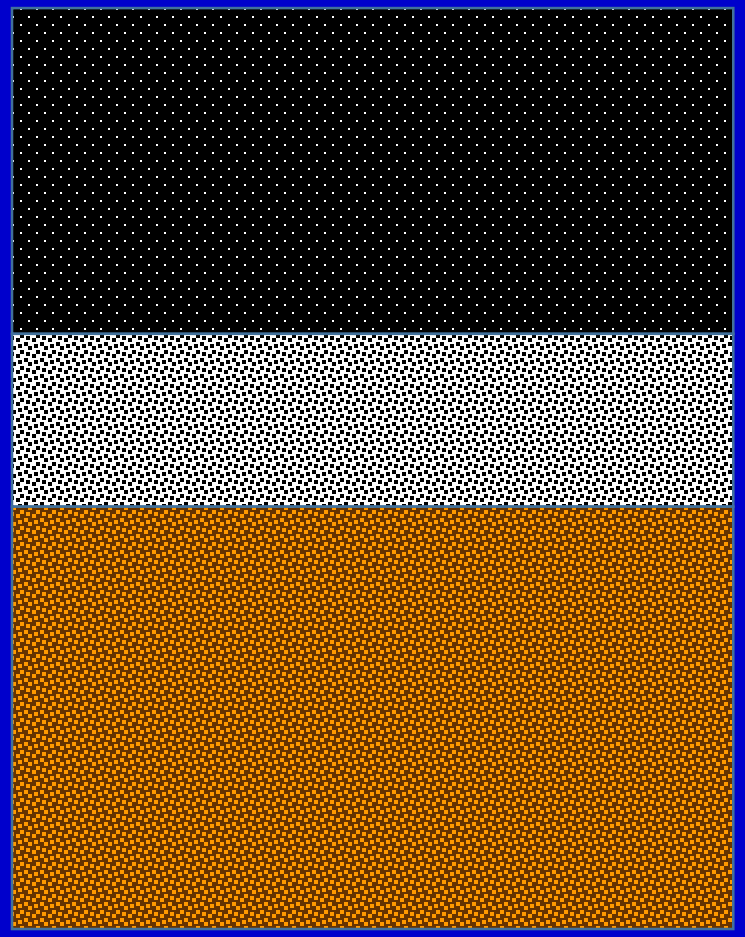
Typical Pavement Sections:

Flexible Pavement

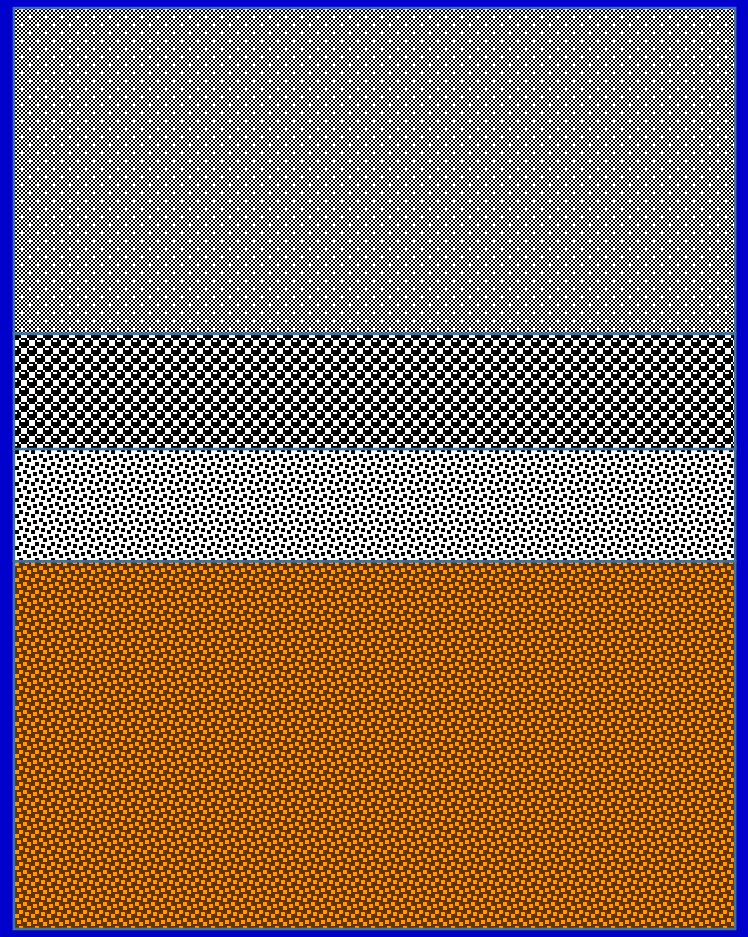


Bituminous Concrete Layers

Subbase

Subgrade

Rigid Pavement



Plain Cement Concrete

Asphalt Treated Permeable Base

Subbase

Subgrade

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Problem Statement:

- Subgrade soils very often have high fines content
- Combination of traffic loads and soil moisture results in pumping
- Pumping = movement of fines with pore water forced from high pressure to low pressure areas (from low permeability subgrade into high permeability subbase)
- Pumping results in migration of subgrade fines up into the subbase

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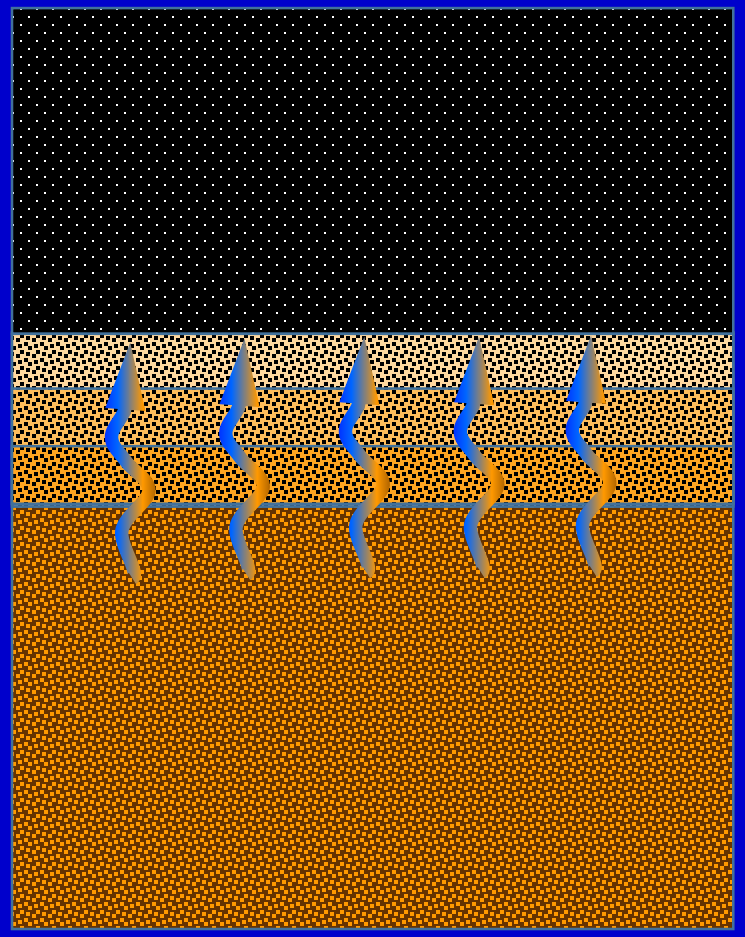
Typical Pavement Sections: Migration Distribution

Uniform along entire pavement length

Flexible Pavement



Bituminous Concrete Layers

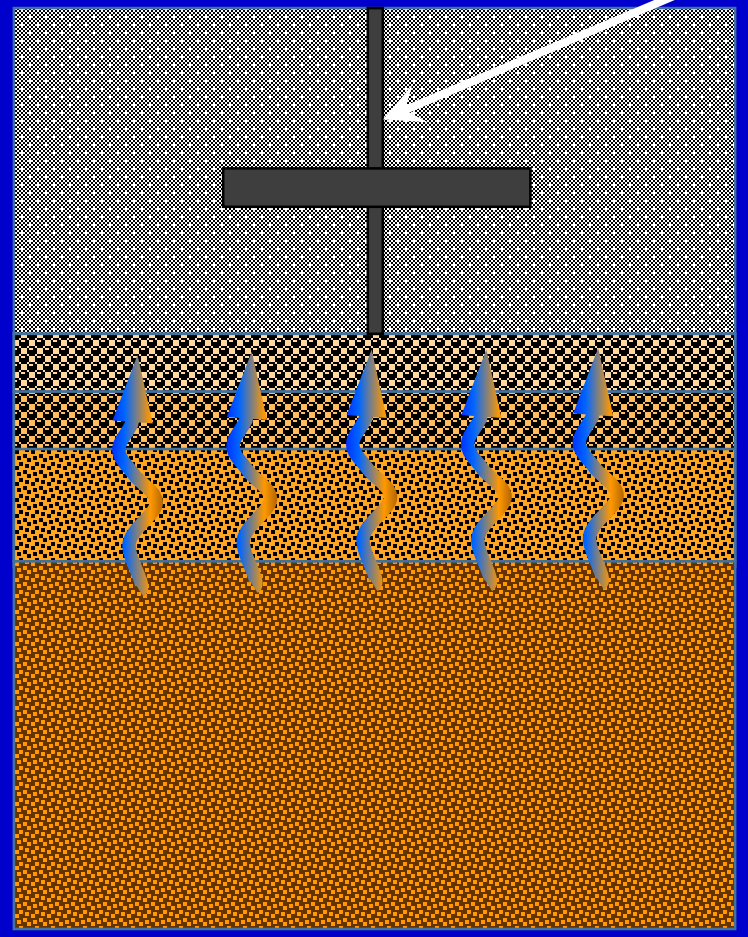
Subbase

Subgrade

Concentrated at pavement joints

Rigid Pavement

Rigid Pavement Joint



Plain Cement Concrete

Asphalt Treated Permeable Base

Subbase

Subgrade

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Mechanism of Fines Migration (Pumping):

- Water incompressible
- As a soil subgrade (a material that has adequate fines) approaches saturation, excess pore pressures generated under load due to low permeability of soil
- Pore pressures “relieved” (partially dissipated) into the adjoining relatively much higher permeability subbase

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Mechanism of Fines Migration (Pumping):

- Subbase acts like pressure relief valve permitting water to drain (pump) upward
- As pressure relieved, fines forced (pumped) up into subbase void space with water
- Not a problem with free draining subgrade materials (low fines content granular material)
- Typical PA subgrade soil has high fines

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Impact of Fines Migration (Pumping): Subbase

- Loss of subbase permeability (unbound coarse aggregate)
- Loss of subbase strength (modulus)
- Properties of subbase are permanently altered
- Subbase can no longer perform as intended (strength or permeability)

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Impact of Fines Migration (Pumping): Subgrade

- Loss of subgrade soil density and stability
- Loss of subgrade soil strength (modulus)
- Loss of fines initiates instability resulting in loss of modulus
- Also, since loss of subbase permeability, more water introduced into subgrade, further reducing stability and strength (modulus)

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Loss of the two primary functions of the subbase:

- **Load Transfer (due to modulus/shear strength reduction)**
- **Drainage (due to loss of permeability)**

Reduction of subgrade stability and modulus/ shear strength:

- **Loss of fines**
- **Increase in moisture (with loss of drainage capability of subbase**

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Research Approach:

- <u>One third scale</u> pavement modeling and traffic loading
- Use of MMLS3 Load Simulator
- Conduct tests on three pavement classes
  - Flexible pavement collector
  - Flexible pavement interstate
  - Rigid pavement interstate
- These provided proof of concept and permit quantifying rate and magnitude of fines migration

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Research Approach:

- Once migration mechanism replicated and quantified, follow with test on flexible pavement collector to assess viability and performance of geotextile separation
- Time and budget constraints did not permit replication of geotextile performance testing on interstate pavement models

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Load Simulation: MMLS3 Load Simulator

- One third scale unidirectional vehicle load simulator
- Continuous loop trafficking (continuous cycling)
- Maximum Wheel Load: 607 lb (2700 kN)
- Wheel Contact Pressure: 101 psi (700 kPa)
- Tire Contact Area: 6.0 in^2 (38.6 cm^2)
- Internal Tire Pressure: 90 psi (621 kPa)
- Load Rate: 7200 wheel loads per hour

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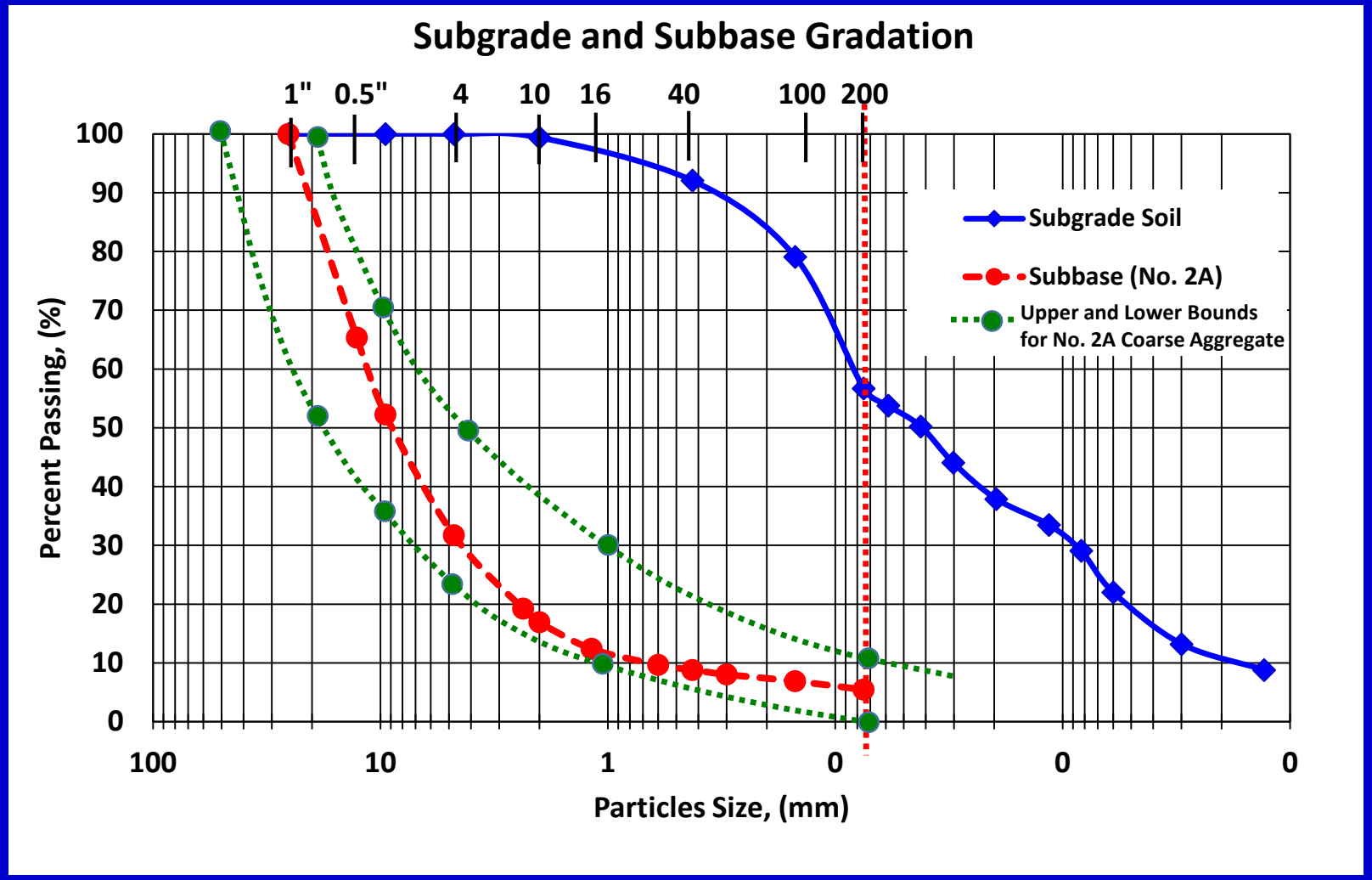
Test Materials:

Subgrade Soil:

AASHTO = A-4; USCS = ML

Subbase:

PENNDOT No. 2A Coarse Aggregate



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Test Materials: Subgrade Soil Properties

- Liquid Limit = 17.1
- Plastic Limit = 16.1
- Plastic Index = 1.0
- Maximum Dry Density = 117.2 pcf *
- Optimum Moisture Content = 11.6 *
- Specific Gravity = 2.79
- Classification: A-4/ML

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* PTM 106 (AASHTO T99)

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Pavement Sections Modelled

Roadway Class Modeled	Pavement Type	Pavement Section	Thickness (in)	ATPB (in)	Total Thickness All Bound Layers, (in)	Subbase (in)	Design Life (years)	ESAL's (millions)	ADT (one direction)
Collector	Flexible	Bituminous Concrete*	8.5	N/A	8.5	6.0	20	1.9	7900
Interstate	Flexible		17.5	N/A	17.5	6.0	20	25.6	25,000
Interstate	Rigid	PCC	13.0	4.0	17.0	4.0	20	36	25,000

* Includes wearing, binder and base layers

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Modelling Approach:

- The MMLS3 Load Simulator works at <u>one third load scale</u>
- One third scale loading does not translate into one third scale pavement sections (layer thicknesses)
- Approach:
  - Maintain minimum 4 inch coarse aggregate subbase layer
  - Model flexible and rigid pavement layers so that stresses at the subgrade-subbase interface are equivalent between the full and one third scale loads

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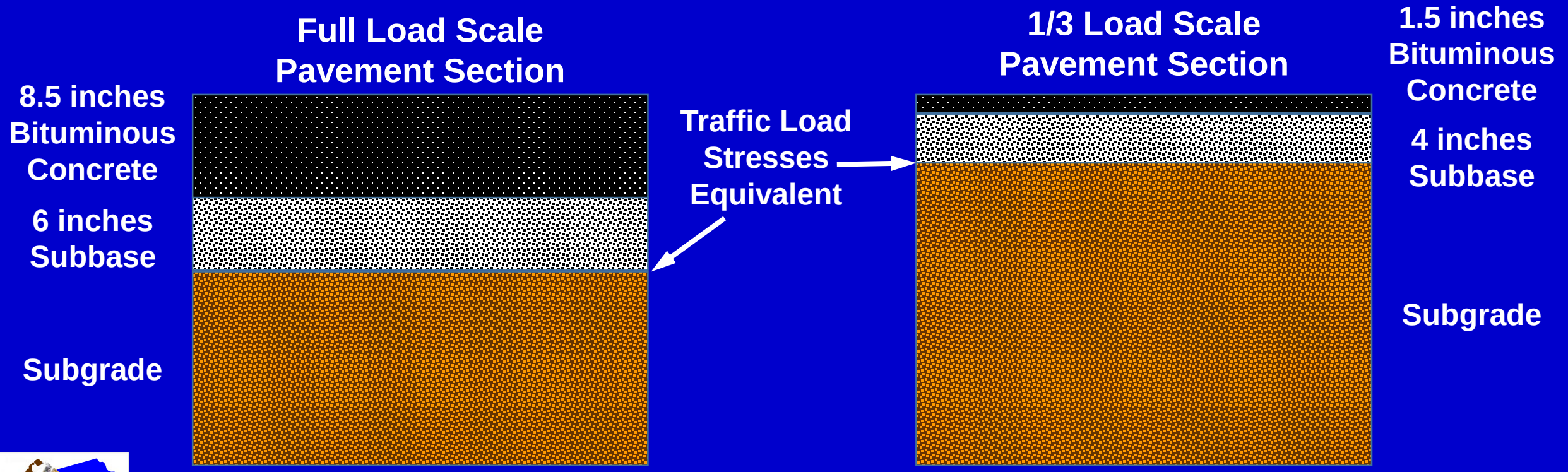
Modelling Approach:

- The test model pavement layer thicknesses were determined so that live load stresses at the subgrade-subbase interface were the same in the full and one-third scale pavement sections
- Example: Flexible pavement collector



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Subgrade-Subbase Interface Stress – Full Scale Collector w/Flexible Pavement

Vertical Stress and Deformation Values for Full-Scale Loading: Collector w/ Flexible Pavement (using Kenlayer program)					
Material	Elastic Modulus (psi)	Poisson's ratio	Layer Thickness (in)	Vertical Stress at the Top of Subgrade (psi)	Deformation at Top of Subgrade (in)
Asphalt	261,068	0.30	8.5	2.66	0.05
Subbase	5,802	0.35	6.0		
Subgrade	2,176	0.45			

Layer Thicknesses for Equivalent Stress at Top of Subgrade for 1/3 Load Scale Model: Collector w/Flexible Pavement (using Kenlayer program)					
Material	Elastic Modulus (psi)	Poisson's ratio	Layer Thickness (in)	Vertical Stress at the Top of Subgrade (psi)	Deformation at Top of Subgrade (in)
Asphalt	261,068	0.30	1.5	2.76	0.02
Subbase	5,802	0.35	4.0		
Subgrade	2,176	0.45			

Layer Thicknesses for 1/3 Load Scale Model at Equivalent Interface Stress Levels

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Subgrade-Subbase Interface Stress – Full Scale Interstate w/Flexible Pavement

Vertical Stress and Deformation Values for Full-Scale Loading: Interstate w/ Flexible Pavement (using Kenlayer program)					
Material	Elastic Modulus (psi)	Poisson's ratio	Layer Thickness (in)	Vertical Stress at the Top of Subgrade (psi)	Deformation at Top of Subgrade (in)
Asphalt	261,068	0.30	17.5	0.96	0.04
Subbase	5,802	0.35	6.0		
Subgrade	2,176	0.45			

Layer Thicknesses for Equivalent Stress at Top of Subgrade for 1/3 Load Scale Model: Interstate w/Flexible Pavement (using Kenlayer program)					
Material	Elastic Modulus (psi)	Poisson's ratio	Layer Thickness (in)	Vertical Stress at the Top of Subgrade (psi)	Deformation at Top of Subgrade (in)
Asphalt	261,068	0.30	2.75	0.98	0.008
Subbase	5,802	0.35	6.0		
Subgrade	2,176	0.45			

Layer Thicknesses for 1/3 Load Scale Model at Equivalent Interface Stress Levels

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Subgrade-Subbase Interface Stress – Full Scale Interstate w/Rigid Pavement

Vertical Stress and Deformation Values for Full-Scale Loading: Interstate w/ Rigid Pavement (using Kenslabs program)					
Material	Elastic Modulus (psi)	Poisson's ratio	Layer Thickness (in)	Vertical Stress at the Top of Subgrade (psi)	Deformation at Top of Subgrade (in)
PCC	4,000,000	0.15	13.5	9.8/7.5*	0.104
ATPB	200,000	0.30	4.0		
Subgrade	2,180	0.45			

* Approach vs Leave Slab

Layer Thicknesses for Equivalent Stress at Top of Subgrade for 1/3 Load Scale Model: Interstate w/Rigid Pavement (using Kenslabs program)					
Material	Elastic Modulus (psi)	Poisson's ratio	Layer Thickness (in)	Vertical Stress at the Top of Subgrade (psi)	Deformation at Top of Subgrade (in)
Marine Plywood	1,450,000	0.37	3.0	10.2	0.105
Subbase	5,800	0.35	4.0		
Subgrade	2,180	0.45			

Layer Thicknesses for 1/3 Load Scale Model at Equivalent Interface Stress Levels

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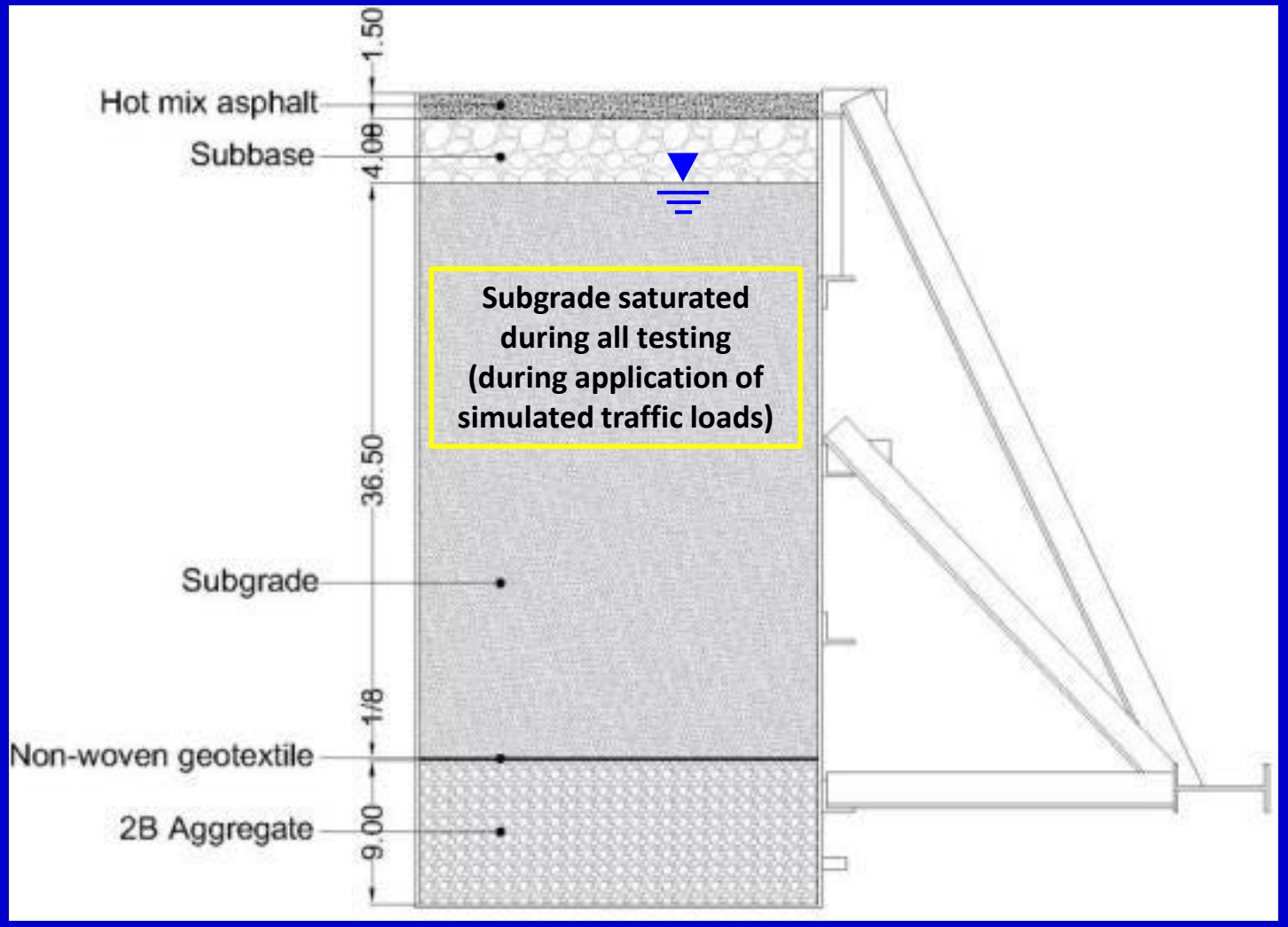
Test Section and Setup:



Typical specimen test bed container cross section (section shown for collector roadway model)

Test Section and Setup:

Empty specimen test bed container for MMLS3 load simulator

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Test Section and Setup:

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Test Section and Setup:

MMLS3 Load Simulator

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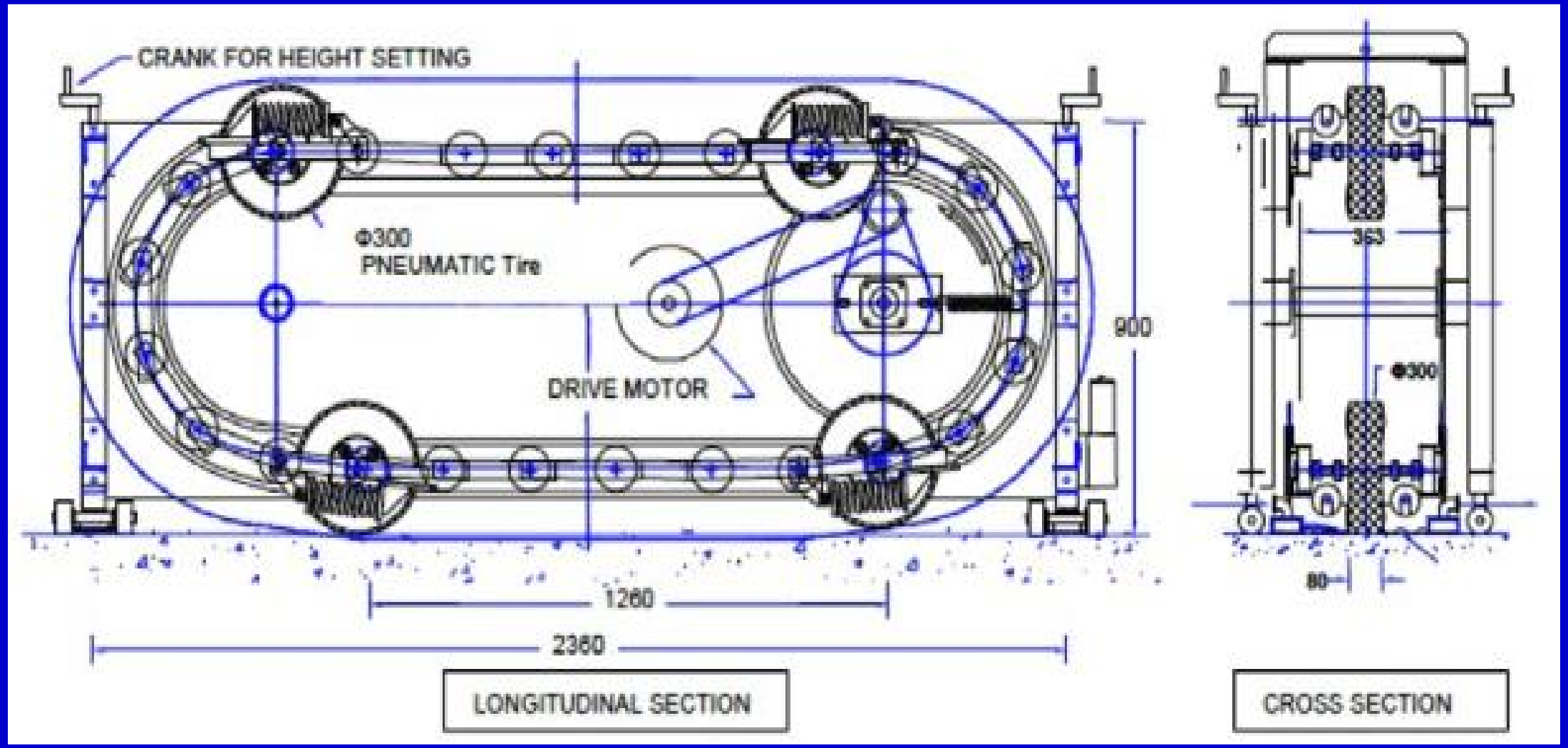
Load Simulator:



Schematic of MMLS3 Load Simulator: Internal Track Mechanism, (units in mm)

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Load Configurations Used in Analysis for Selected Trucks

Truck Type	Nominal Load per Wheel (lbs)	Tire Contact Pressure (psi)	Contact Radius (for Kenlayer Analysis), (in)	Effective Length - Width (for Kenslabs Analysis), (in)	Tandem Spacing, (in)	Wheel Spacing (center-to-center), (in)
2-Axle, 4 Tire	9,000	123.28	4.82	10.30 - 7.09	–	–
5-Axle Tractor-Semitrailer	4,250	123.28	3.31	7.07 - 4.87	51.57	16.75

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Approximate Equivalent ESALs Corresponding to Cycles of MMLS3 for Each Class and Type of Roadway (AASHTO 1993)

Roadway Class and Pavement Type	Truck Axle Configuration for Stress Calculations	Axle Load (kips)	Axle equivalency (load) factor	MMLS3 number of cycles	Estimated equivalent ESALs	Ratio of ESALs to MMLS3 cycles
Collector Road – Flexible Pavement	2 Axle – 4 Tire	18	1.00	432,000	432,000	1.00
Interstate Highway – Flexible Pavement	5 Axle, Tractor Semi-trailer	34	1.09	1,600,000	1,744,000	1.09
Interstate Highway – Rigid Pavement	5 Axle, Tractor Semi-trailer	34	1.97	1,000,000	1,970,000	1.97

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Summary of Test Configurations

Roadway Type	Task	Full Scale Pavement Section				One-Third Load Scale Pavement		
		Pavement Type	Pavement Layer Thickness	ATPB Thickness (inches)	Subbase Thickness (inches)	Pavement Type	Pavement Layer Thickness	Subbase Thickness (inches)
Collector	2B, 2C and 3*	Flexible – Bituminous Concrete	8.5	N/A	6.0	Flexible – Bituminous Concrete	1.5	4.0
Interstate	2D	Flexible – Bituminous Concrete	17.5	N/A	6.0	Flexible – Bituminous Concrete	2.75	6.0
Interstate	2E	Rigid – Portland Cement Concrete	13.5	4.0	4.0	Marine Plywood	3.0	4.0

*Note: Task 3 includes Class 4A Geotextile separator between the subgrade and subbase layers

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Approximate Portion of Pavement Life Modeled Sections were Subject to Load

	Full Scale Pavement		Modeled Pavement			
Roadway Class and Pavement Type	Design Life (years)	Design ESAL's (millions)	MMLS3 number of cycles	Estimated equivalent ESALs	Approx. Portion of Design Life Tested	
					(years)	(%)
Collector Road – Flexible Pavement	20	1.9	432,000	432,000	4.5	22.7
Interstate Highway – Flexible Pavement	20	25.6	1,600,000	1,744,000	1.4	6.8
Interstate Highway – Rigid Pavement	20	36	1,000,000	1,970,000	1.1	5.5

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Testing Results

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Task 2B - Collector Roadway					
Pavement Section	Material	Scaled Thickness, (in)	Modeled Thickness, (in)		
	Bituminous Concrete	1.5			
	2A Subbase	4.0			
	Subgrade	36.5	N/A		

Migration of Subgrade into Subbase, (%)								
	Number Load Cycles (x 1000)							
	100		200		300		432	
Particle Size Range	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)
No. 30 to No. 40	0.00	0.00	0.00	0.00	0.31	0.17	0.81	0.44
No. 40 to No. 50	0.00	0.00	0.00	0.00	0.44	0.25	1.05	0.56
No. 50 to No. 100	0.00	0.00	0.23	0.13	0.66	0.47	1.12	0.85
No. 100 to No. 200	0.16	0.09	0.41	0.28	0.81	0.58	1.22	1.04
< No. 200	2.81	1.78	3.28	2.19	3.61	2.65	4.05	3.22
All Sizes	2.97	1.87	3.92	2.60	5.83	4.12	8.25	6.11

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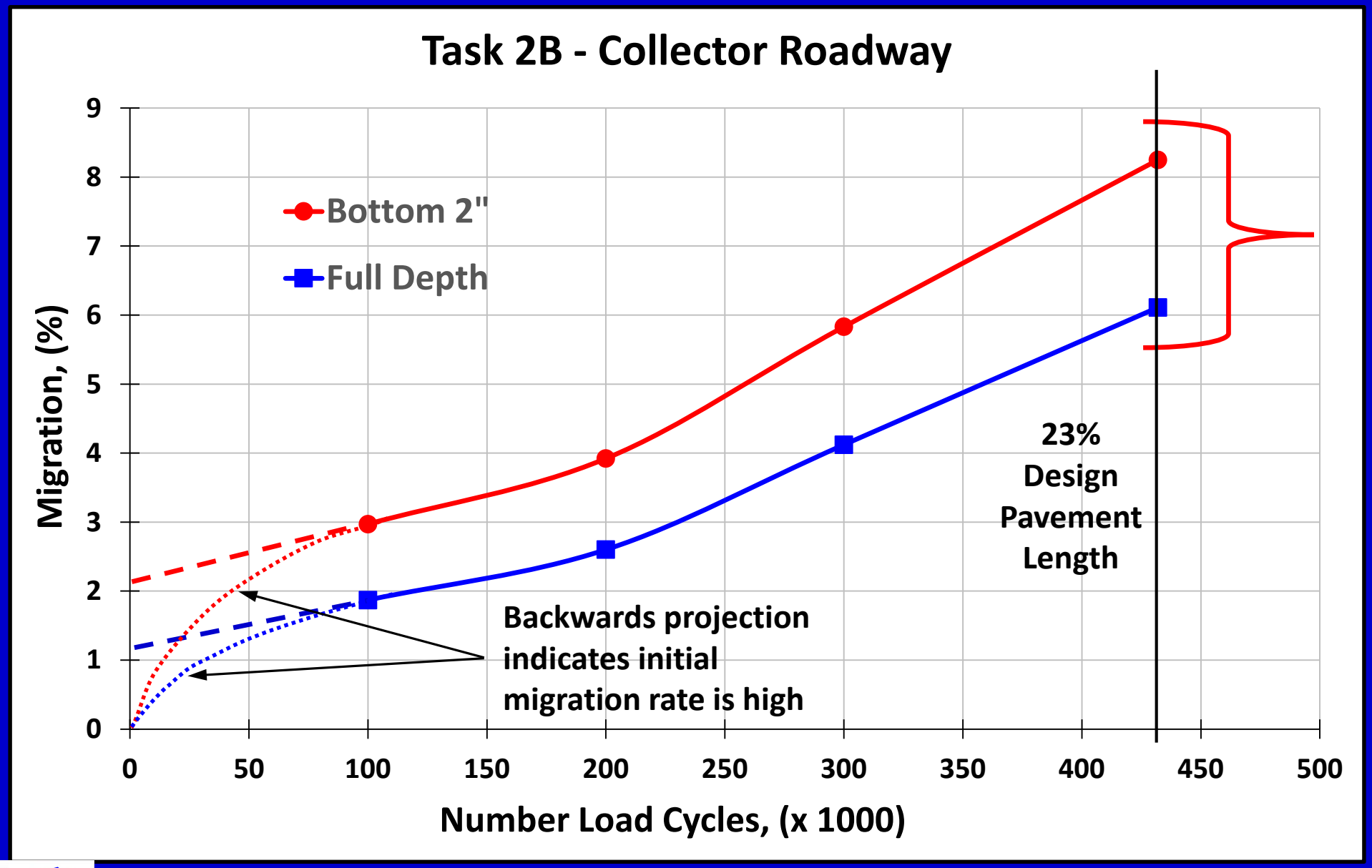

Theorize that increase in migration rate past 200k load cycles may be related to stress increase at subgrade-subbase resulting from pavement rutting (thinning of pavement) – need to complete review of instrumentation to see if this is indicated

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Task 2C - Collector Roadway (Repeat of Task 2B) Confirm Results of Task 2B

Pavement Section	Material	Scaled Thickness, (in)	Modeled Thickness, (in)
	Bituminous Concrete	1.5	
	2A Subbase	4.0	
	Subgrade	36.5	N/A

Migration of Subgrade into Subbase, (%)

	Number Load Cycles (x 1000)							
	100		200		300		432	
Particle Size Range	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)
No. 30 to No. 40	0.00	0.00	0.00	0.00	0.27	0.13	0.94	0.47
No. 40 to No. 50	0.00	0.00	0.00	0.00	0.55	0.28	1.03	0.57
No. 50 to No. 100	0.00	0.00	0.31	0.15	0.63	0.44	1.12	0.87
No. 100 to No. 200	0.09	0.04	0.50	0.34	0.90	0.65	1.29	1.09
< No. 200	2.63	1.60	3.37	2.31	3.56	2.66	4.31	3.39
All Sizes	2.72	1.64	4.18	2.80	5.91	4.16	8.69	6.39

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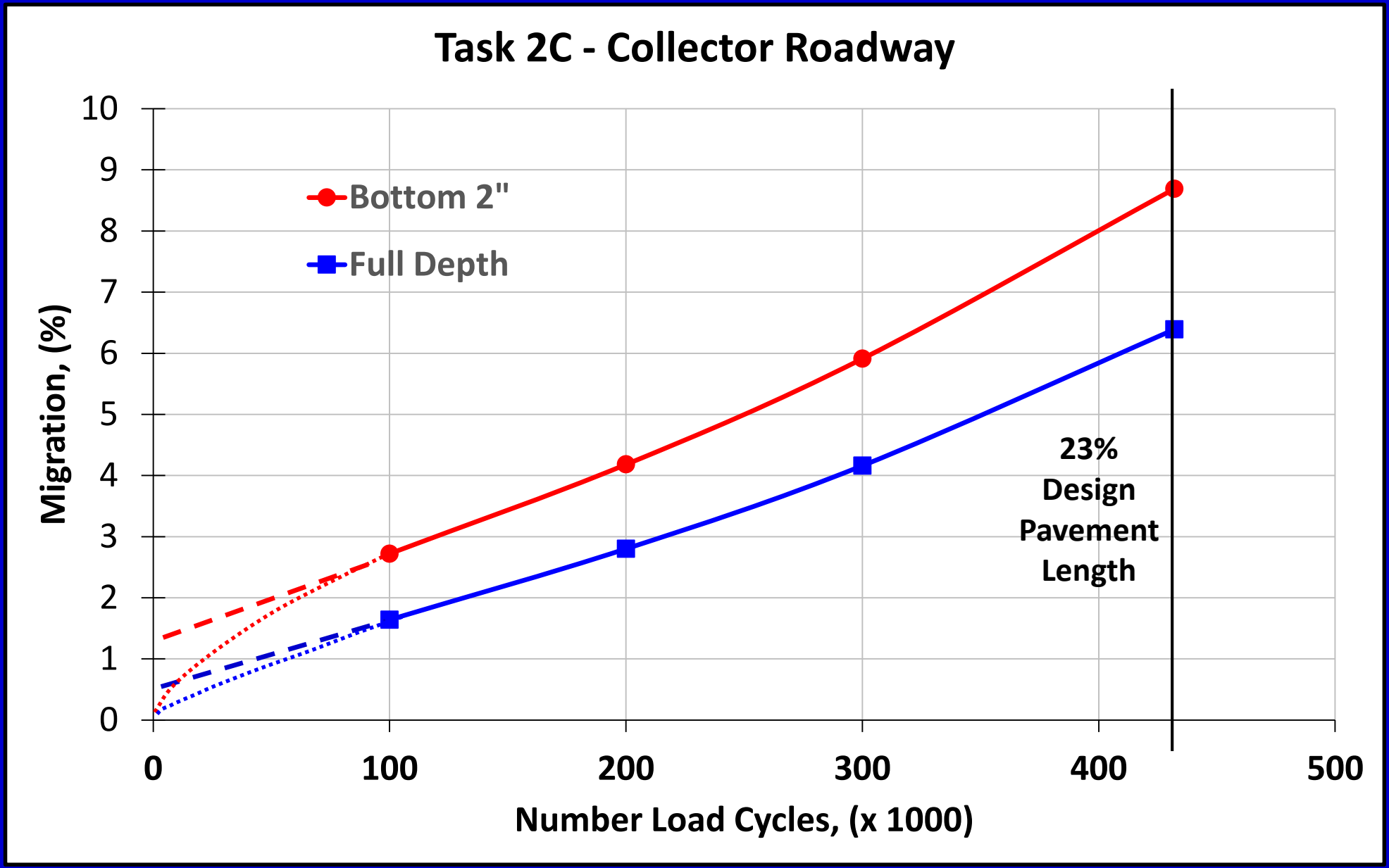

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Task 2D - Interstate Roadway w/Flexible Pavement					
Pavement Section	Material	Scaled Thickness, (in)	Modeled Thickness, (in)		
	Bituminous Concrete	2.5			
	2A Subbase	4.0			
	Subgrade	36.5	N/A		

Migration of Subgrade into Subbase, (%)								
	Number Load Cycles (x 1000)							
	150		450		900		1600	
Particle Size Range	Bottom 3 inches, (%)	Full Depth, (%)	Bottom 3 inches, (%)	Full Depth, (%)	Bottom 3 inches, (%)	Full Depth, (%)	Bottom 3 inches, (%)	Full Depth, (%)
No. 30 to No. 40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No. 40 to No. 50	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.18
No. 50 to No. 100	0.00	0.00	0.00	0.00	0.49	0.30	0.67	0.41
No. 100 to No. 200	0.00	0.00	0.36	0.28	0.62	0.47	0.85	0.62
< No. 200	0.93	0.46	1.38	1.05	1.68	1.29	2.11	1.61
All Sizes	0.93	0.46	1.74	1.33	2.79	2.06	4.01	2.82

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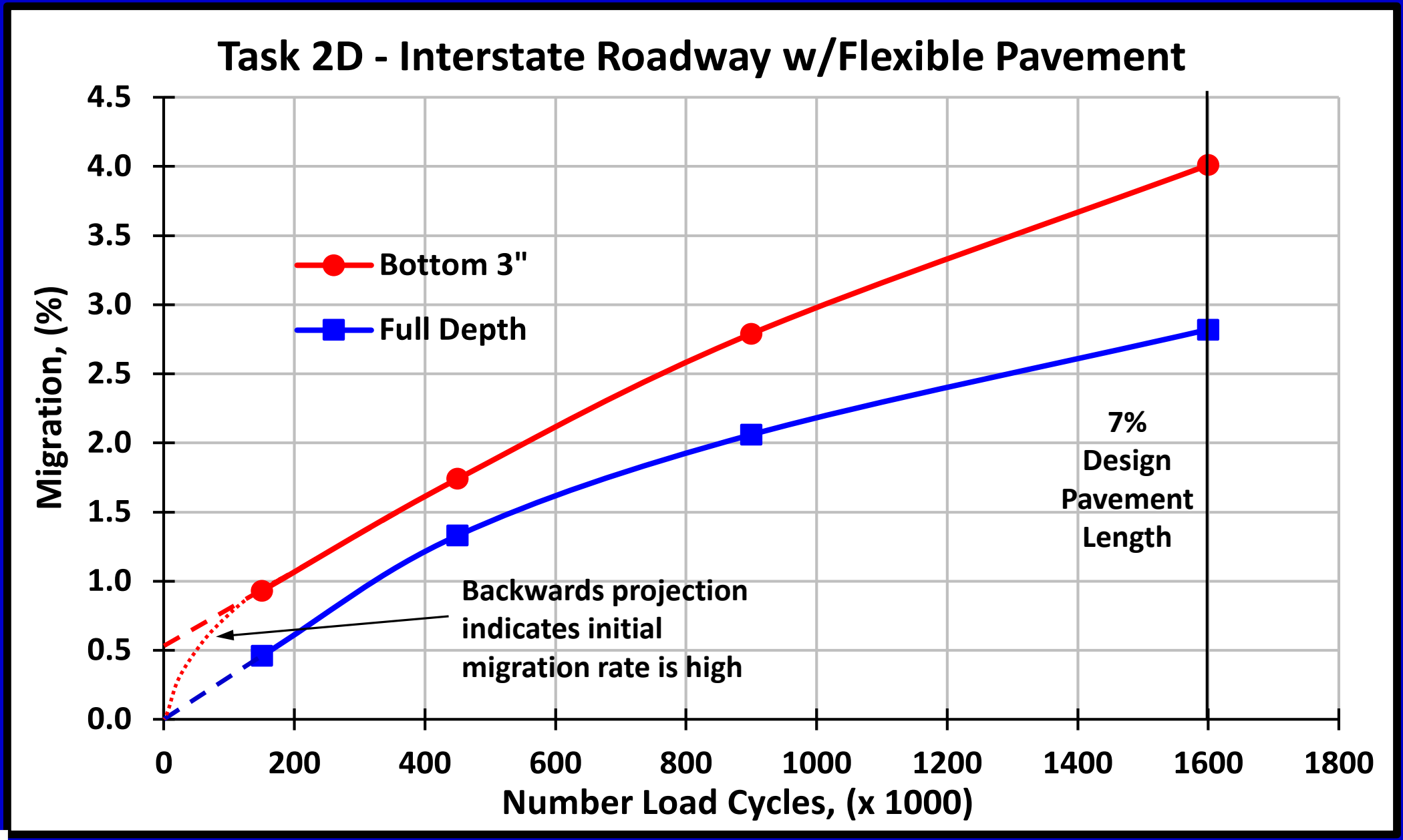

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Task 2E - Interstate Roadway w/Rigid Pavement			
Pavement Section	Material	Scaled Thickness, (in)	Modeled Thickness, (in)
	Marine Plywood	3.0	
	2A Subbase	4.0	
	Subgrade	36.5	N/A

Migration of Subgrade into Subbase, (%) - Avg All Samples						
	Number Load Cycles (x 1000)					
	200		500		1000	
Particle Size Range	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)
No. 30 to No. 40	0.43	0.22	0.84	0.43	1.50	0.80
No. 40 to No. 50	0.48	0.24	0.94	0.50	1.58	0.86
No. 50 to No. 100	0.55	0.41	1.04	0.80	1.73	1.35
No. 100 to No. 200	0.66	0.57	1.16	0.99	1.88	1.69
< No. 200	3.20	2.27	4.06	3.18	4.93	3.99
All Sizes	5.32	3.70	8.04	5.89	11.62	8.70
Note:	3.0 inches of marine grade plywood used to model rigid concrete pavement					

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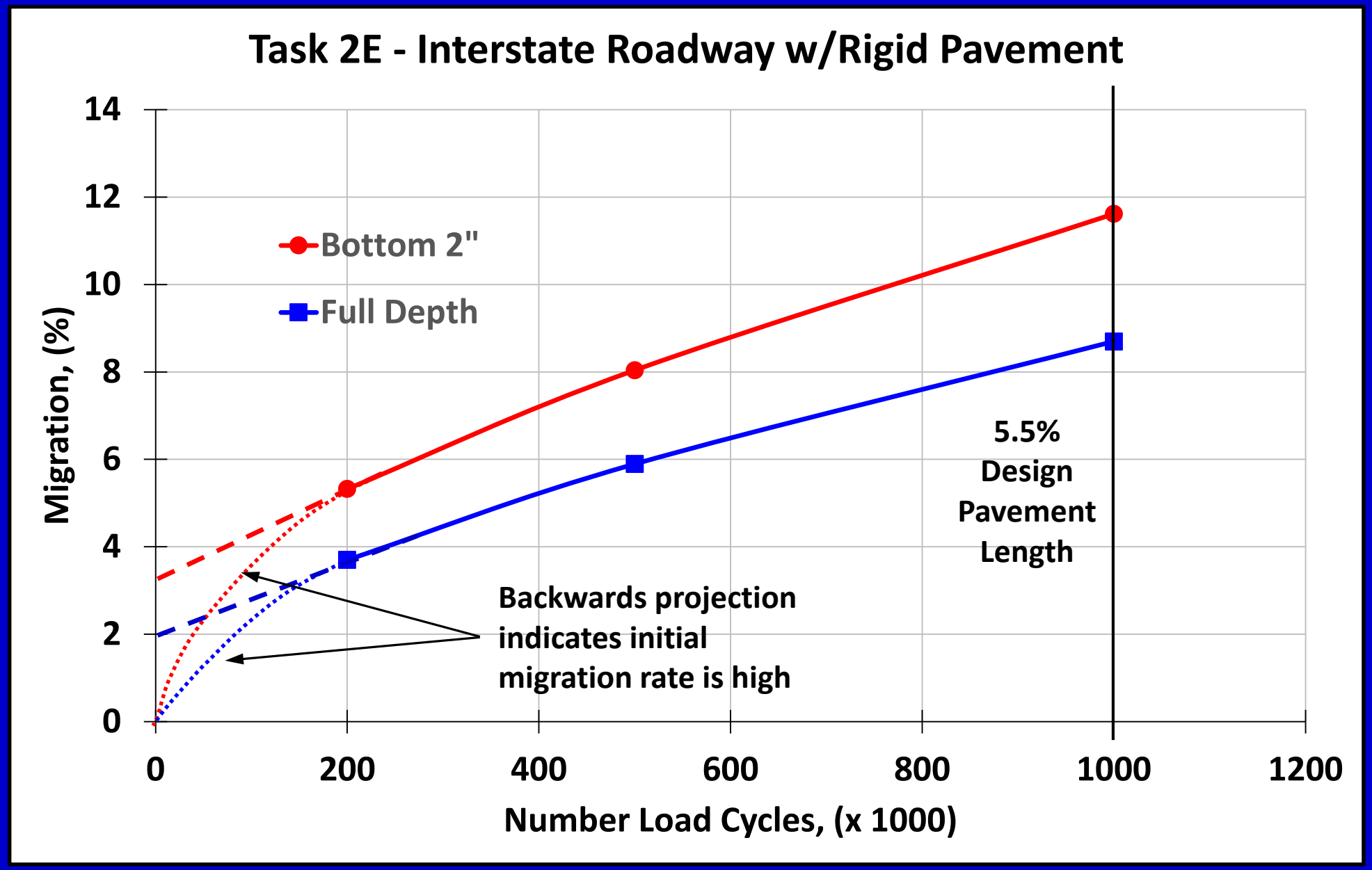

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Task 3 - Collector Roadway (Repeat of Task 2B but w/Class 4A Geotextile Separator)								
Pavement Section	Material		Scaled Thickness, (in)		Modeled Thickness, (in)			
	Bituminous Concrete		1.5					
	2A Subbase		4.0					
	Subgrade		36.5		N/A			
Migration of Subgrade into Subbase, (%)								
	Number Load Cycles (x 1000)							
	100		200		300		432	
Particle Size Range	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)	Bottom 2 inches, (%)	Full Depth, (%)
No. 30 to No. 40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No. 40 to No. 50	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.05
No. 50 to No. 100	0.00	0.00	0.00	0.00	0.12	0.06	0.18	0.14
No. 100 to No. 200	0.00	0.00	0.20	0.10	0.36	0.24	0.45	0.32
< No. 200	0.97	0.55	1.45	0.88	1.74	1.16	1.89	1.30
All Sizes	0.97	0.55	1.65	0.98	2.22	1.46	2.62	1.81

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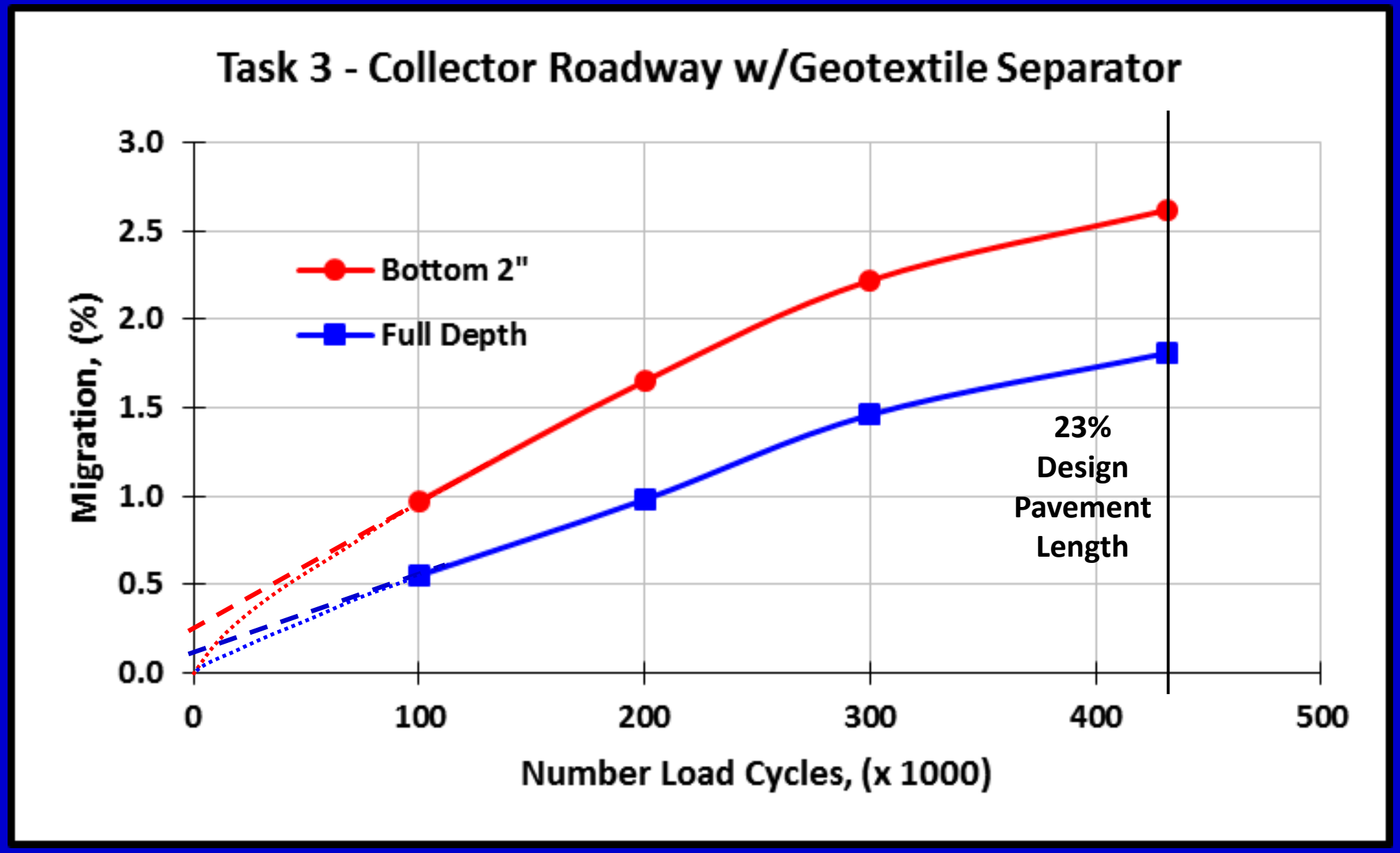

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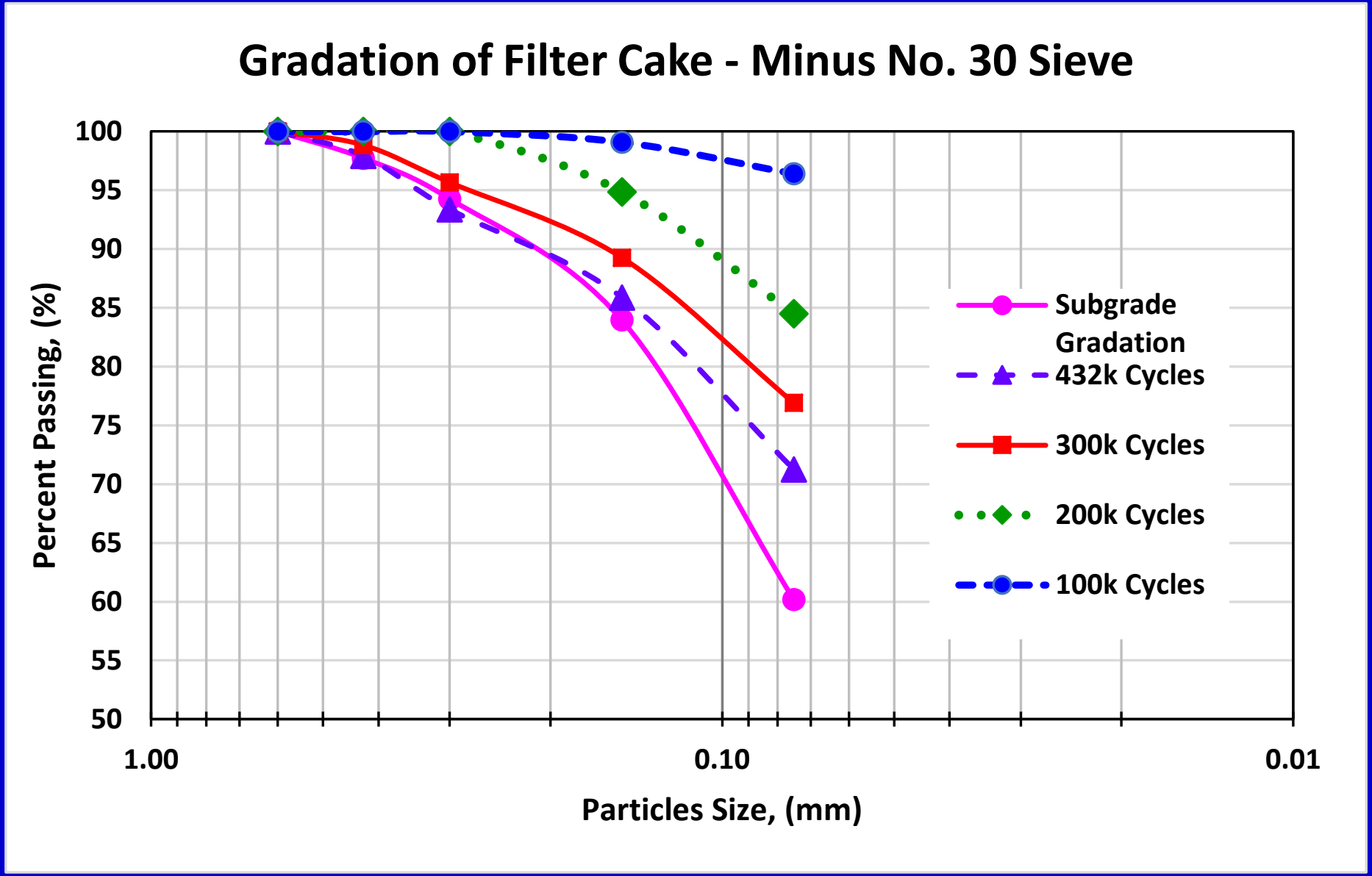

Filter cake gradation includes both entrapped and retained material

Gradations of entrapped and retained portions were nearly identical after

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Gradation of Filter Cake						
Particle Size		Percent Passing of Minus 30 Matrial				
Sieve No.	Sieve Size, (mm)	Original Subgrade	100k Cycles	200k Cycles	300k Cycles	432k Cycles
30	0.600	100.0	100.0	100.0	100.0	100.0
40	0.425	97.7	100.0	100.0	98.8	97.9
50	0.300	94.3	100.0	100.0	95.7	93.4
150	0.150	84.0	99.1	94.9	89.3	85.9
200	0.075	60.2	96.4	84.5	76.9	71.3

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Collector w/ Flexible Pavement – Comparison with and without Geotextile Separator									
No. of cycles	Total Migration, (%)								
	Task 3 (w/Geotextile Separator)			Task 2B (w/o Geotextile Separator)			Task 2C - repeat test of 2B (w/o Geotextile Separator)		
	Top 2 inches	Bottom 2 inches	Full Depth	Top 2 inches	Bottom 2 inches	Full Depth	Top 2 inches	Bottom 2 inches	Full Depth
100,000	0.12	0.97	0.55	0.41	2.97	1.87	0.54	2.72	1.64
200,000	0.31	1.65	0.98	1.18	3.92	2.60	1.40	4.18	2.80
300,000	0.69	2.22	1.46	2.23	5.83	4.12	2.37	5.91	4.16
432,000	0.98	2.62	1.81	3.57	8.25	6.11	3.99	8.69	6.39

Detailed Information

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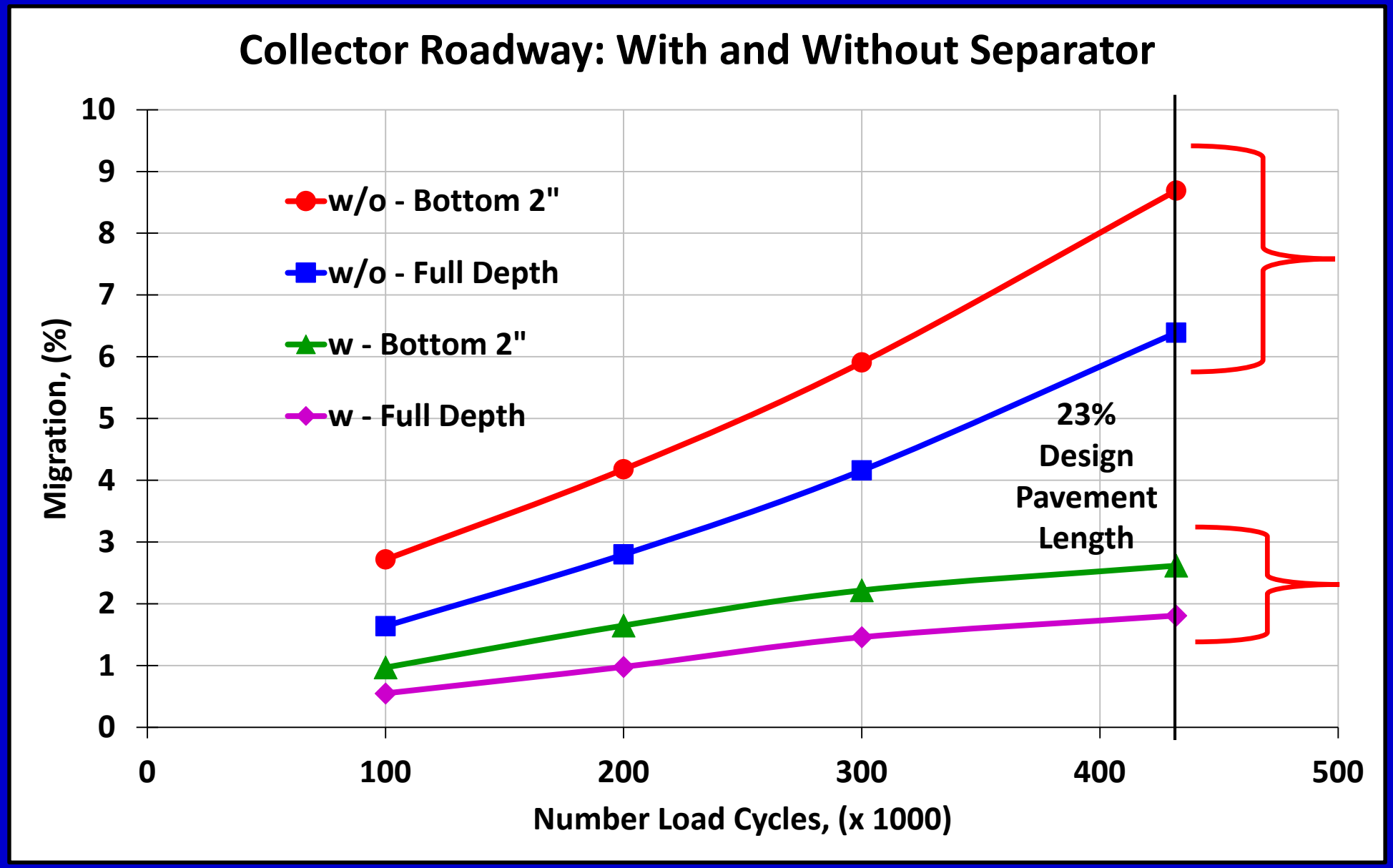

Without geotextile separator

With geotextile separator

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Summary of Migration Results – All Tasks

Task	Pavement Class	Pavement Type	Subbase Thickness, (inches)	Total Load Cycles, (x1000)	Load Cycles as % Design Life	Percent Migration - minus 30 material (fines and fine sands)			Percent Migration - minus 200 material (fines)		
						Bottom Half Subbase	Top Half Subbase	Full Depth Subbase	Bottom Half Subbase	Top Half Subbase	Full Depth Subbase
2B	Collector	Bituminous	4	432	22.7	8.3	3.6	6.1	4.1	2.2	3.2
2C	Collector	Bituminous	4	432	22.7	8.7	4.0	6.4	4.3	2.4	3.4
3	Collector*	Bituminous	4	432	22.7	2.6	1.0	1.8	1.9	0.7	1.3
2D	Flexible Interstate	Bituminous	6	1600	6.8	4.0	1.6	2.8	2.1	1.1	1.6
2E	Rigid Interstate**	Marine Plywood	4	1000	5.5	11.6	5.8	8.7	4.9	3.1	4.0

*** With Class 4A Geotextile Separator (12 oz Non-woven Needle Punched Fabric)**

**** Migration at rigid pavement joint**

Mostly fines migration through geotextile – occurs during early load cycles until filter cake forms

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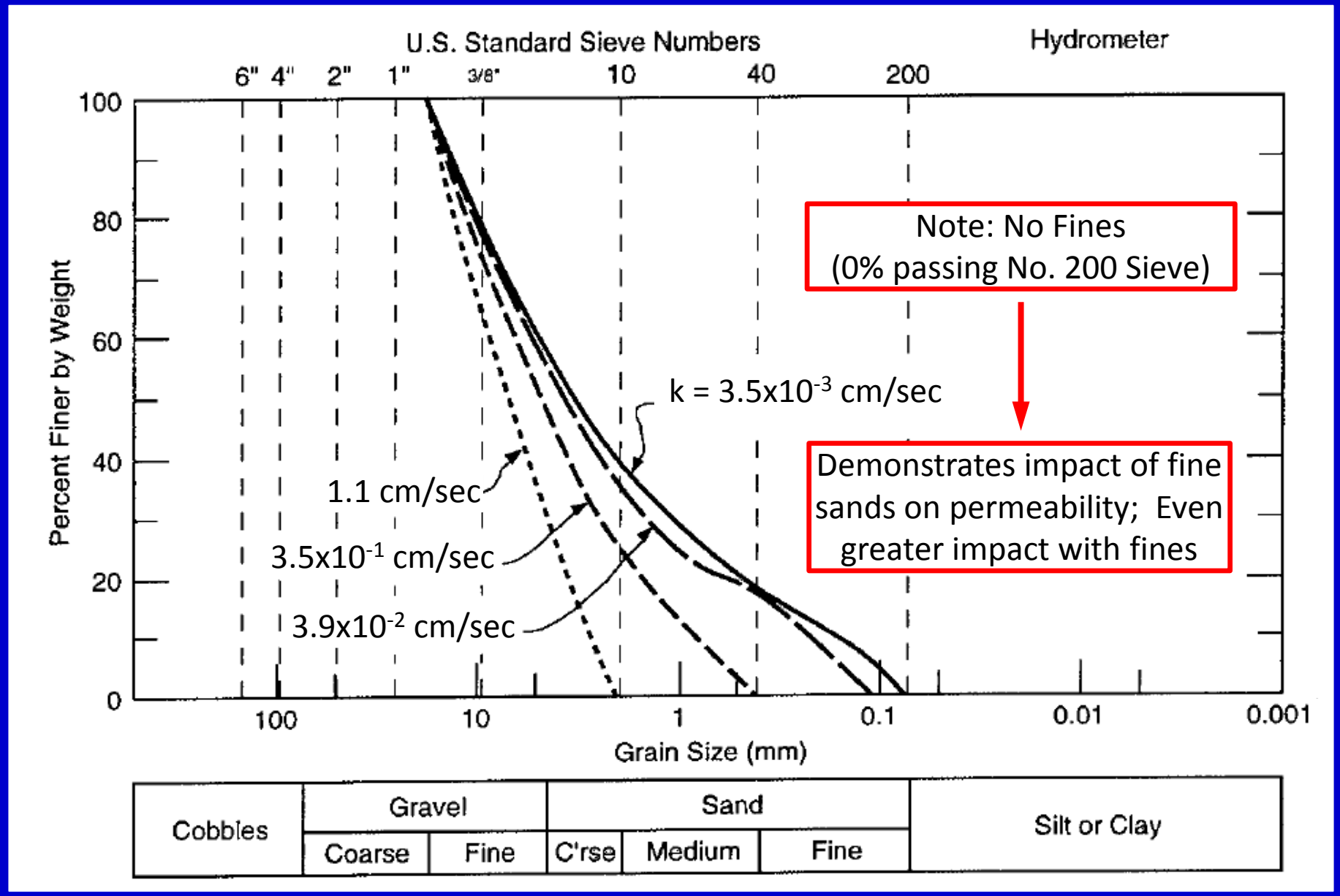
Permeability vs Gradation of Granular Base

Source: CRRL



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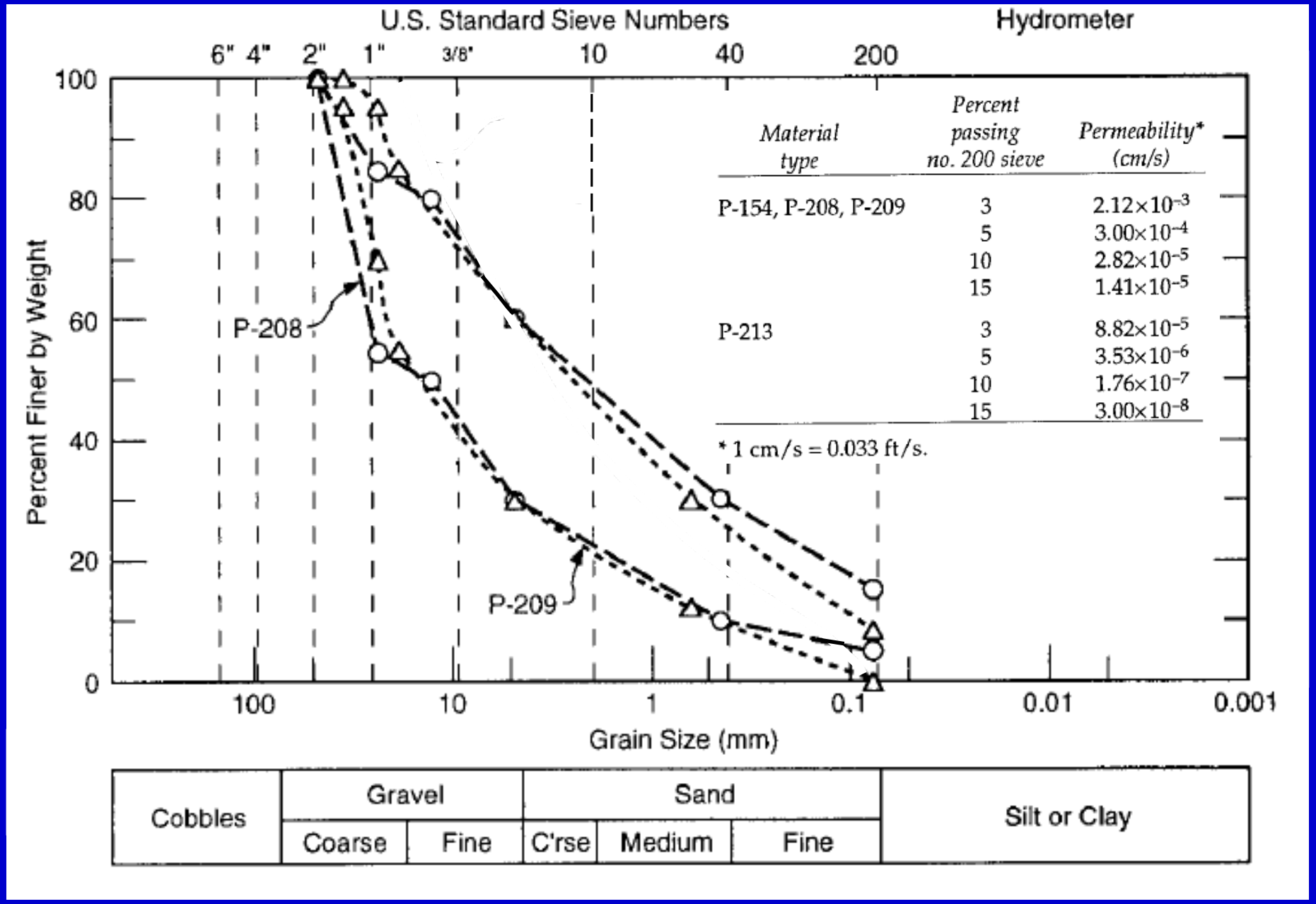
FAA Standard Gradations

Permeability at Various Fine Contents

Note: P-208 and P-209 contain non-plastic fines while P-213 contains plastic fines

Source: CRRL



Material type	Percent passing no. 200 sieve	Permeability* (cm/s)
P-154, P-208, P-209	3	2.12×10^{-3}
	5	3.00×10^{-4}
	10	2.82×10^{-5}
	15	1.41×10^{-5}
P-213	3	8.82×10^{-5}
	5	3.53×10^{-6}
	10	1.76×10^{-7}
	15	3.00×10^{-8}

* 1 cm/s = 0.033 ft/s.

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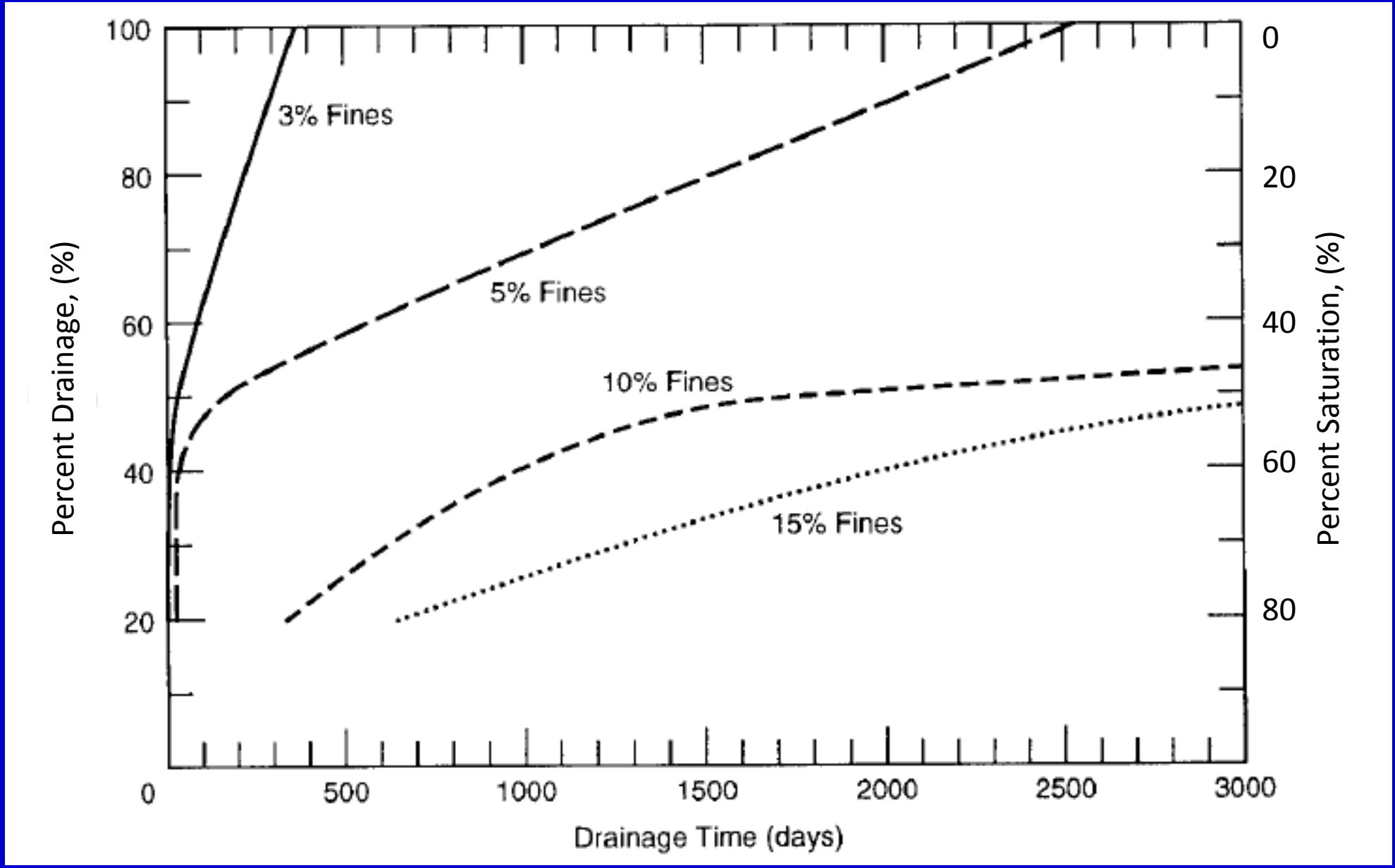
Effect of Fines Content on Drainage of Granular Base Materials

Source: CRRL



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Effect of Fines on Permeability of Granular Base Materials

Based upon review of literature, well established that:

- **Beyond 5 to 6 percent fines content, permeability decreases rapidly and is controlled controlled by the fines**
- **As fines content increases, permeability decreases**
- **As fines content increases, Resilient Modulus (Mr) and shear strength decreases**

In addition:

- **PENNDOT Subbase Type C No. 2A Coarse Aggregate – Can contain up to 10% fines, up to 10% deleterious shale and up to 3% clay lumps = total potential permissible fines content = 23 percent**
- **In practice 7 to 8 percent fines is typical, and all deleterious shale would have to degrade to clay to reach 23 percent fines**

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Effect of Fines on Permeability of Granular Base Materials

- **Beyond 5 to 6 percent fines content, permeability decreases rapidly; controlled by the fines**
- **PENNDOT Subbase Type C No. 2A Coarse Aggregate – Typical 7 to 8 percent fines**

Task	Pavement Class	Pavement Type	Subbase Thickness, (inches)	Total Load Cycles, (x1000)	Load Cycles as % Design Life	Percent Migration - minus 30 material (fines and fine sands)			Percent Migration - minus 200 material (fines)		
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2E	Rigid Interstate**	Marine Plywood	4	1000	5.5	11.6	5.8	8.7	4.9	3.1	4.0

Task 3 clearly demonstrates effectiveness of a geotextile separator

However even the limited migration takes fines in excess of 10%

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Implementation

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Implementation:

- Recommendation to use geotextile subgrade-subbase separation for all pavement types
- Apply full width including and unpaved shoulders (any subgrade-subbase interface
- Must be cost effective
- Need cost-benefit analysis

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Cost-Benefit Analysis - Assumptions:

- Impact from fines contamination are three-fold:
  1) Decrease in subbase strength (reduction of subbase modulus)
  2) Loss of drainage capacity for subbase (clogging)
  3) Decrease in subgrade strength (reduction of resilient modulus)

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Cost-Benefit Analysis - Assumptions:

- Migration of fines from subgrade up into subbase is achieved by incorporating a separating layer between the subgrade and subbase materials
- Class 4, Type A geotextile to be used as separator consisting of 12 oz non-woven needle-punched material (like thick felt)
- Geotextile provides no reinforcing function – only separation

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Cost-Benefit Analysis - Assumptions:

- DARWIN used for all pavement designs
- CBR = 5 used for all subgrades
- Standard values for layer coefficients and other properties were used in the study

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Cost-Benefit Analysis - Assumptions:

- The detrimental impacts of fines migration on the longevity of the pavement systems were <u>incrementally</u> quantified using DARWIN
- The adverse effects were added to the model one at a time to assess the cumulative impact

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Cost-Benefit Analysis - Assumptions:

- Quantification of the impacts were evaluated using the following approach:

  1) 50 percent loss of subbase strength due to fines contamination

  2) Reduction in drainage capacity

  3) 20 percent reduction in subgrade strength (CBR reduced from 5 to 4)

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Summary Cost Breakdown: Collector

Item	Multiplier	Unit Cost/s.y.
Wearing		11.85
Binder		13.79
Base		21.72
Subbase		10.52
Base Drain		* 2.52
Shoulders		* 16.97
Subtotal		$77.55
Mobilization	0.05	3.88
MPT	0.06	4.65
D & C Engineering/Admin	0.20	15.51
Total		$101.59
Class 4A Geotextile		2.04
Cost w/Separator	2.0 % Increase	$103.63

* Equivalent per s.y. cost for 12 foot lane

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Summary Cost Breakdown: Collector

Condition	Pavement Life (years)	Section Cost ($/sy)	Reconstruct Cost ($/sy)	Total Life Cost ($/sy)
With Class 4A Geotextile	20	$103.63	N/A	$103.63
Without Geotextile (Invalid Assumption)*	6	$101.59		
Adjusted life for contamination period** (Reconstruct 0.87 times in 20 yrs)	10.7	$101.59	$88.38	$189.97
Adjust for inflation (Annual rate = 2.9%)	10.7	$101.59	$117.63	$219.22
Increase Base Thickness (from 4" to 6.5")***	20	$119.38		$119.38
Increase Subbase Thickness (from 6" to 14")***	20	$121.28		$121.28

Based upon life cycle cost analysis, compared to most favorable alternate option ($119 s.y. by increasing the base thickness), use of geotextile separator results in a minimum 13% cost savings for equivalent pavement life.

* Fines do not migrate instantaneously – takes time with repeated load cycles

** Assumes subbase contaminated at rate of 1 inch per year

*** Does not include additional excavation or shoulder costs

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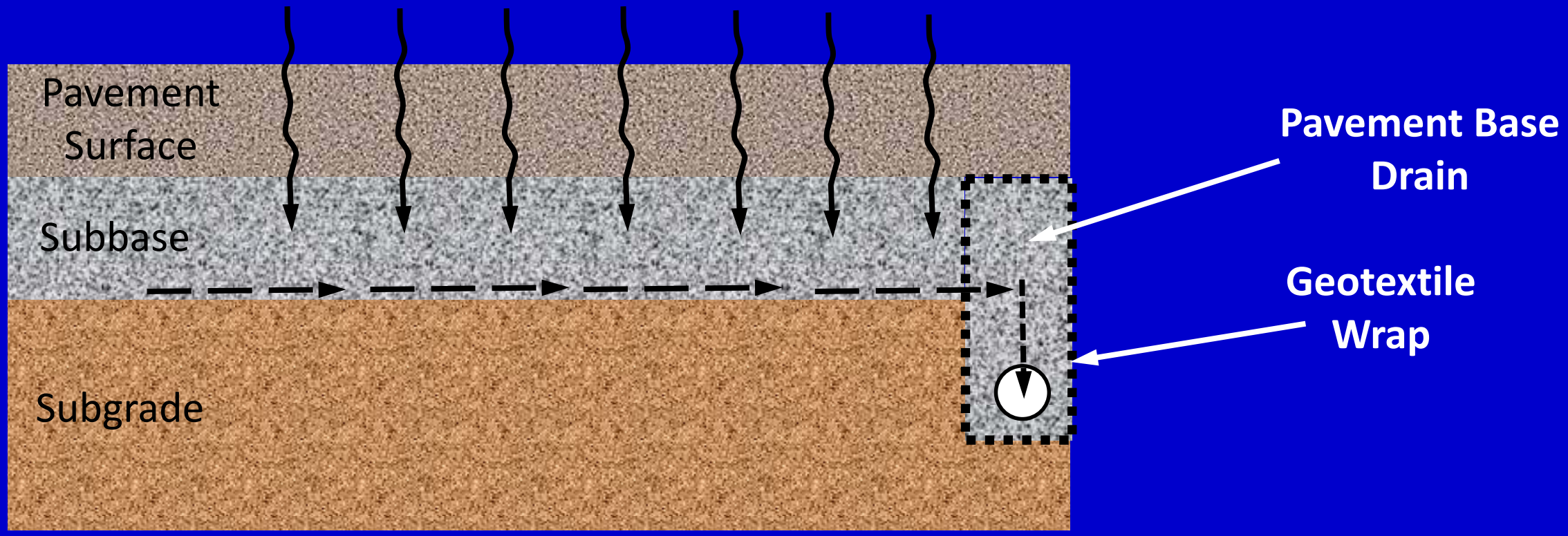
What is the END GAME?

Water will find a way!



Personal crusade to improve pavement performance (as a Geotechnical Engineer)

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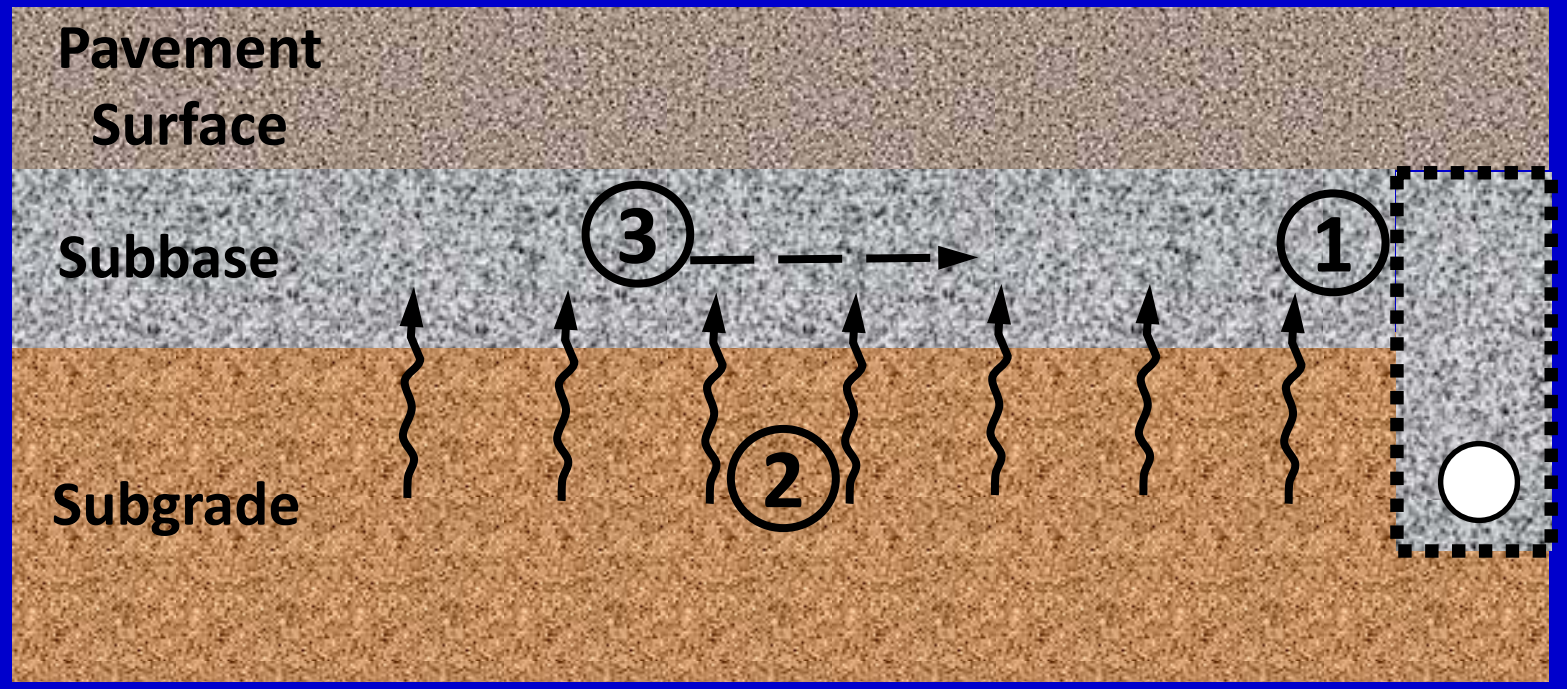

Three Challenges

1. In-service permeability of geotextile wrap around pavement base drain – resolved 2016 with revision to geotextile specs
2. Migration of fines up into subbase – close to resolution?
3. Permeability of subbase – up to 10% fines, 3% clay lumps and 10% deleterious shale

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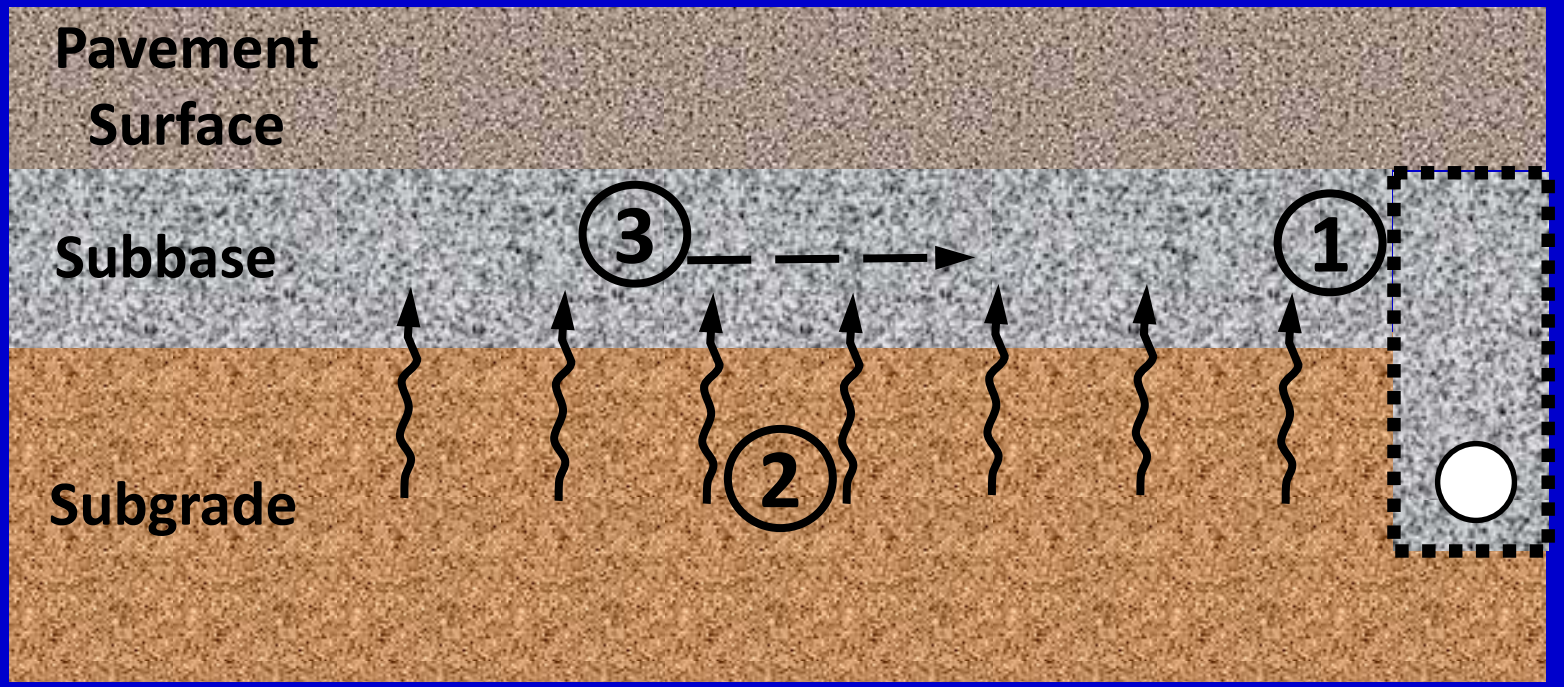

Three Challenges

These three components, while independent, have a common functional impact

DRAINAGE!

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END GAME?

Assure effective drainage of pavement sections

Still need to address item 3 (Subbase Gradation/Quality) to meet this goal

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Let’s make pavements great again…

…use a geotextile separator!

…and better subbase!

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