S.A.M.E. Transportation Resiliency Forum

Cement Stabilization

Coppell, TX
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Cement Council of Texas

CCT Members

ASH GROVE
A CRH COMPANY

CAPITOL AGGREGATES INC

CEMEX

GCC

Martin Marietta

STC

TEXAS LEHIGH CEMENT COMPANY LP

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Presentation Outline

- Terms
- TxDOT Study
- Materials
- Construction
- Field Testing
- Projects
- Lime + Cement
- Summary
- CCT Staff
- Questions

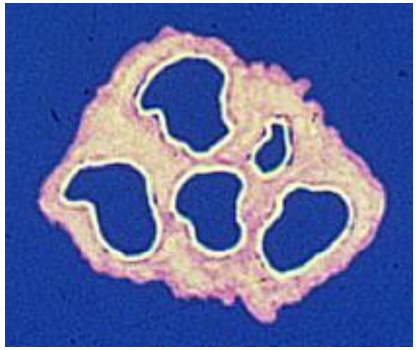
Concrete vs. Soil-Cement

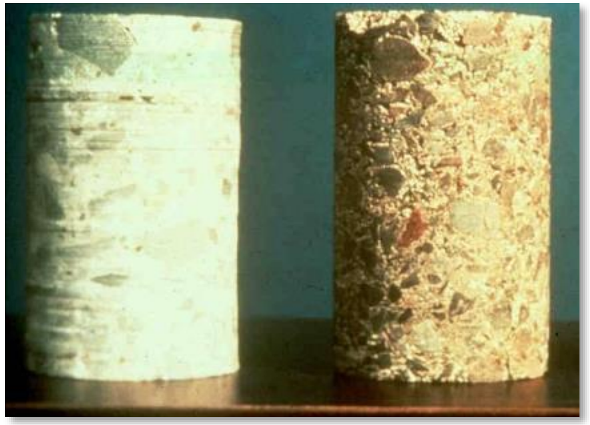
CEMENTITIOUS GEL OR PASTE

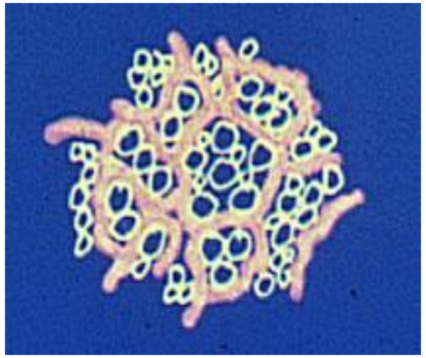
- All particles coated
- All voids filled
- Aggregates glued together

HYDRATION PRODUCTS

- Not all particles coated
- All voids not filled
- Agglomerations linked together







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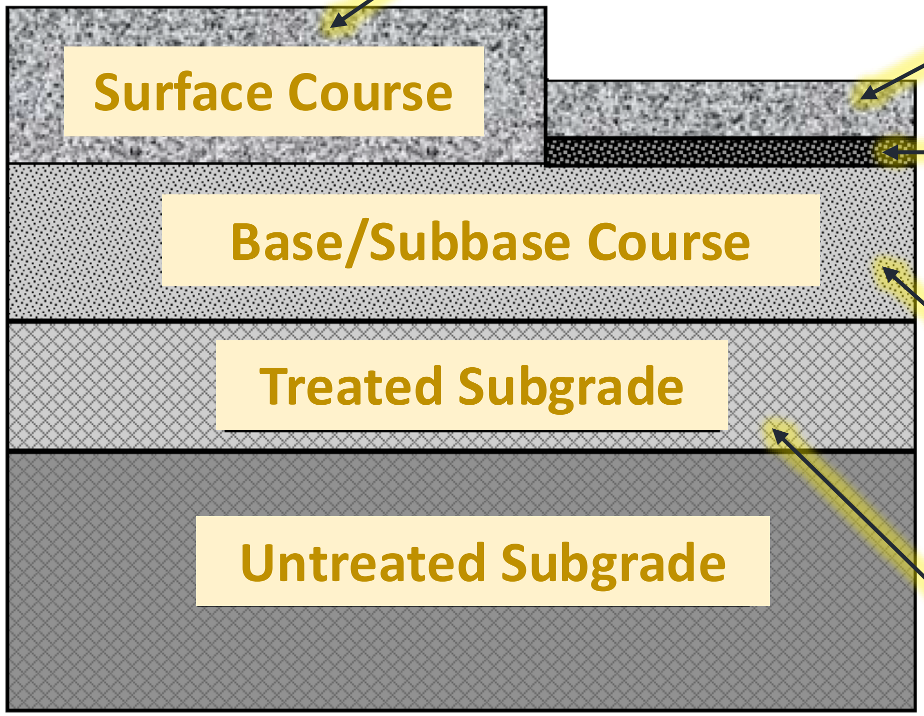
Cement-Based Materials in Pavements

Pavement Surface - Conventional, Pervious, Precast, and Roller-Compacted Concrete (RCC)

Concrete Overlays

Bituminous



- RCC
- Cement-Treated Base
- Full-Depth Reclamation (FDR)
- Lean Concrete Base
- Lightweight Cellular Concrete

- Cement-Stabilized Subgrade
- Cement-Modified Soil

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Rigid Pavements – TxDOT Base Layer Requirements

TxDOT recognizes the one of the following layers for concrete slab support:

- 4 in of hot-mix asphalt (HMA) or asphalt stabilized base (ASB)
- Or a minimum 1 in hot-mix asphalt bond breaker over 6 in. of cement treated base (CTB)

Field performance evaluations of concrete pavements have revealed that durable, stabilized, non-erodable base is essential to the long-term performance of concrete pavement.

If the base does not provide good support, the concrete pavement will be compromised, and long-term performance will be compromised.

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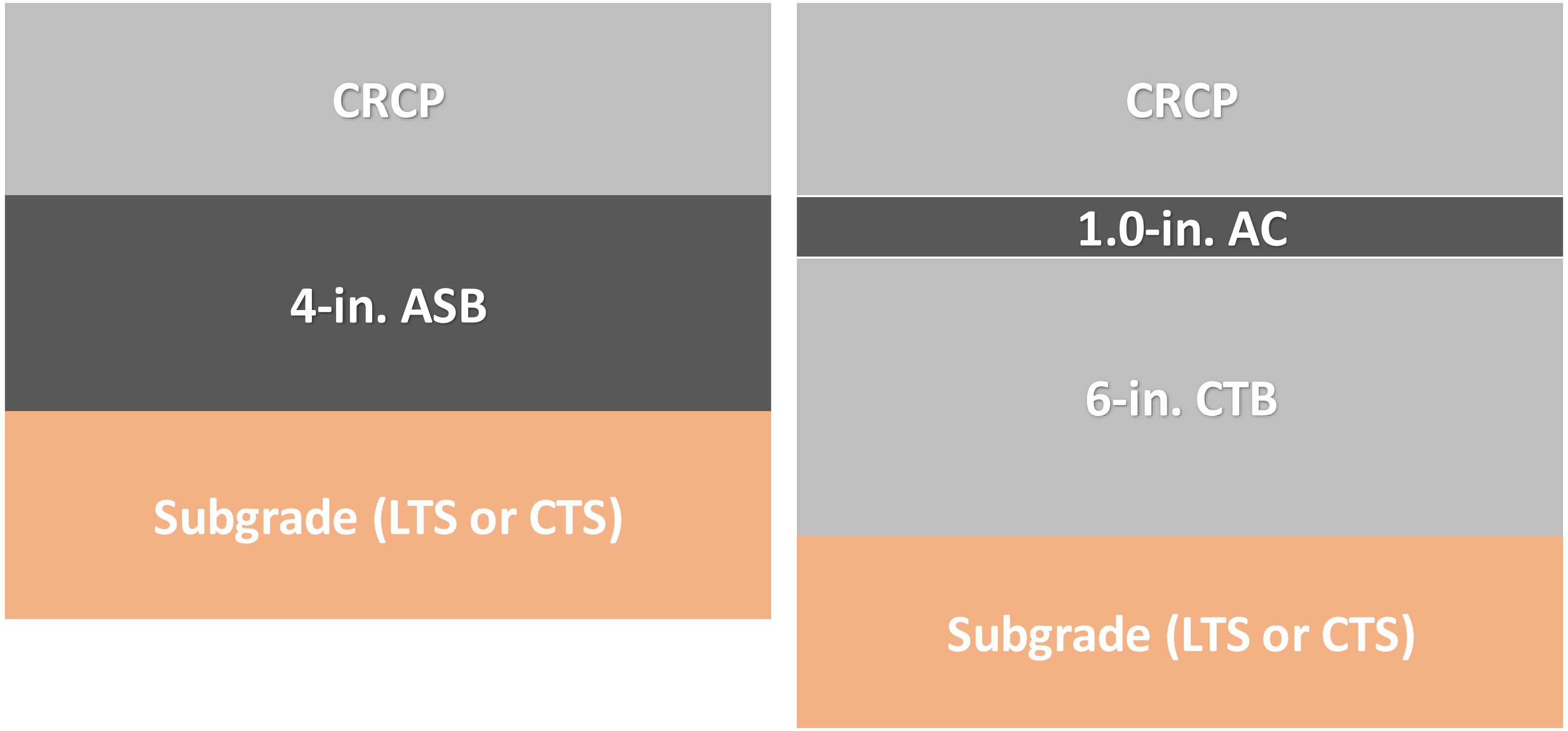
Base Type Selection

- ≥ 4-in. HMA or ASB
- ≥ 1.0-in. HMA or ASB + 6-in. CTB



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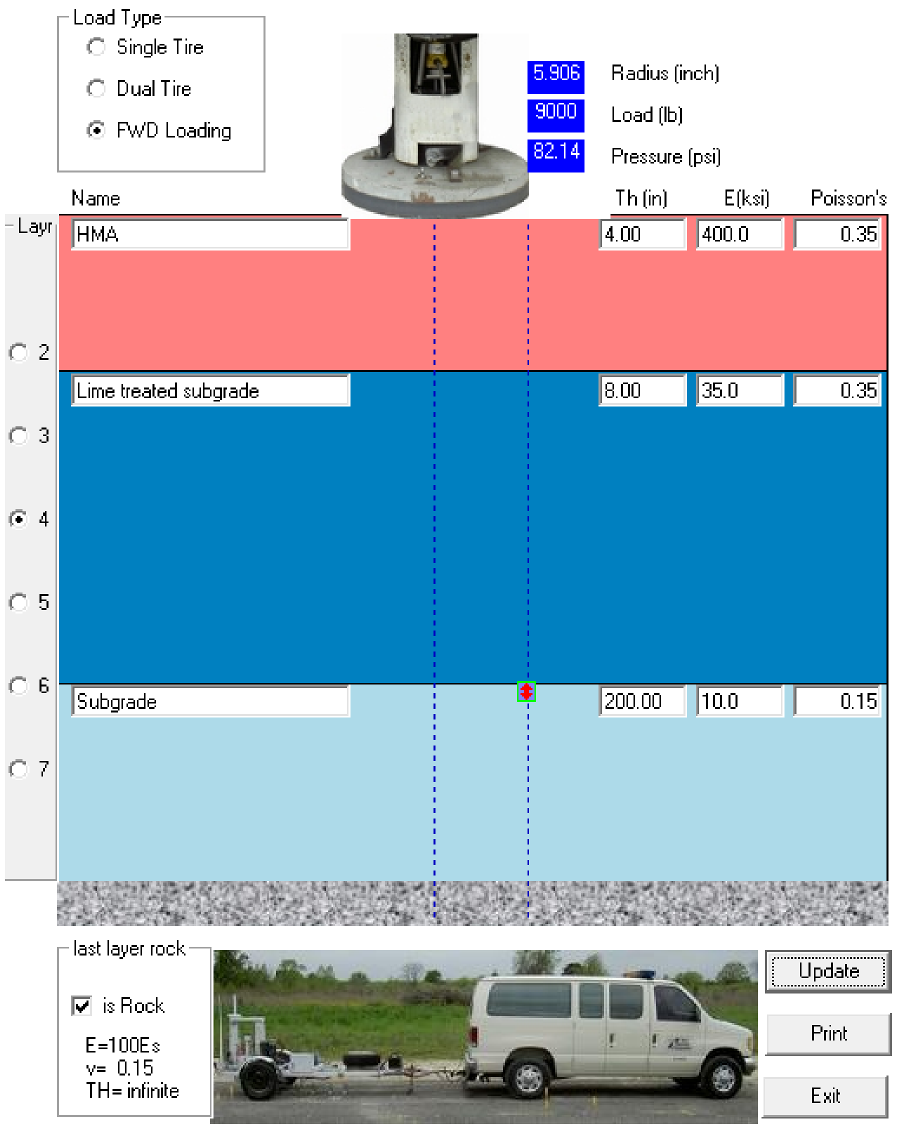
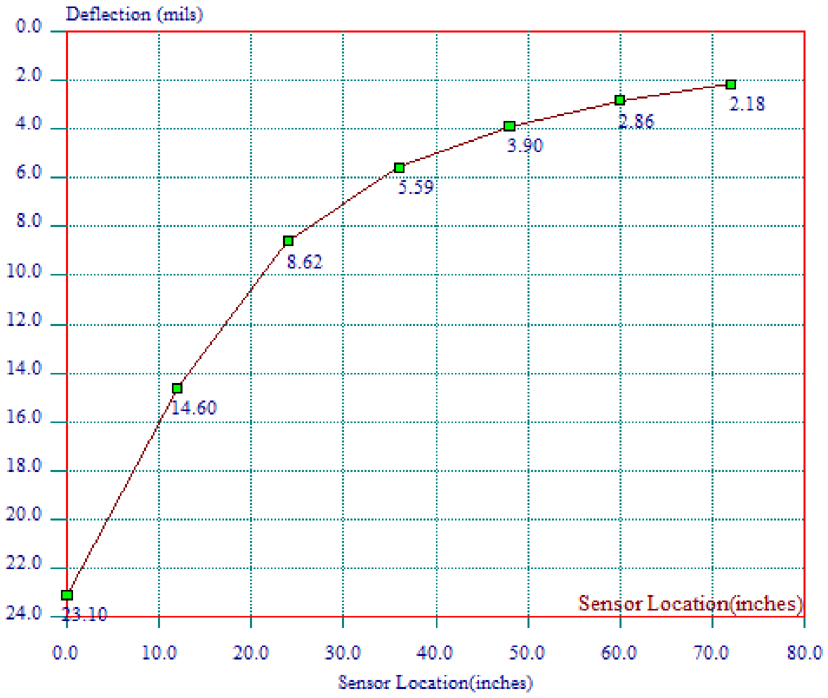
HMA Base + lime treated subgrade (LTS) FWD deflections: 23 mils

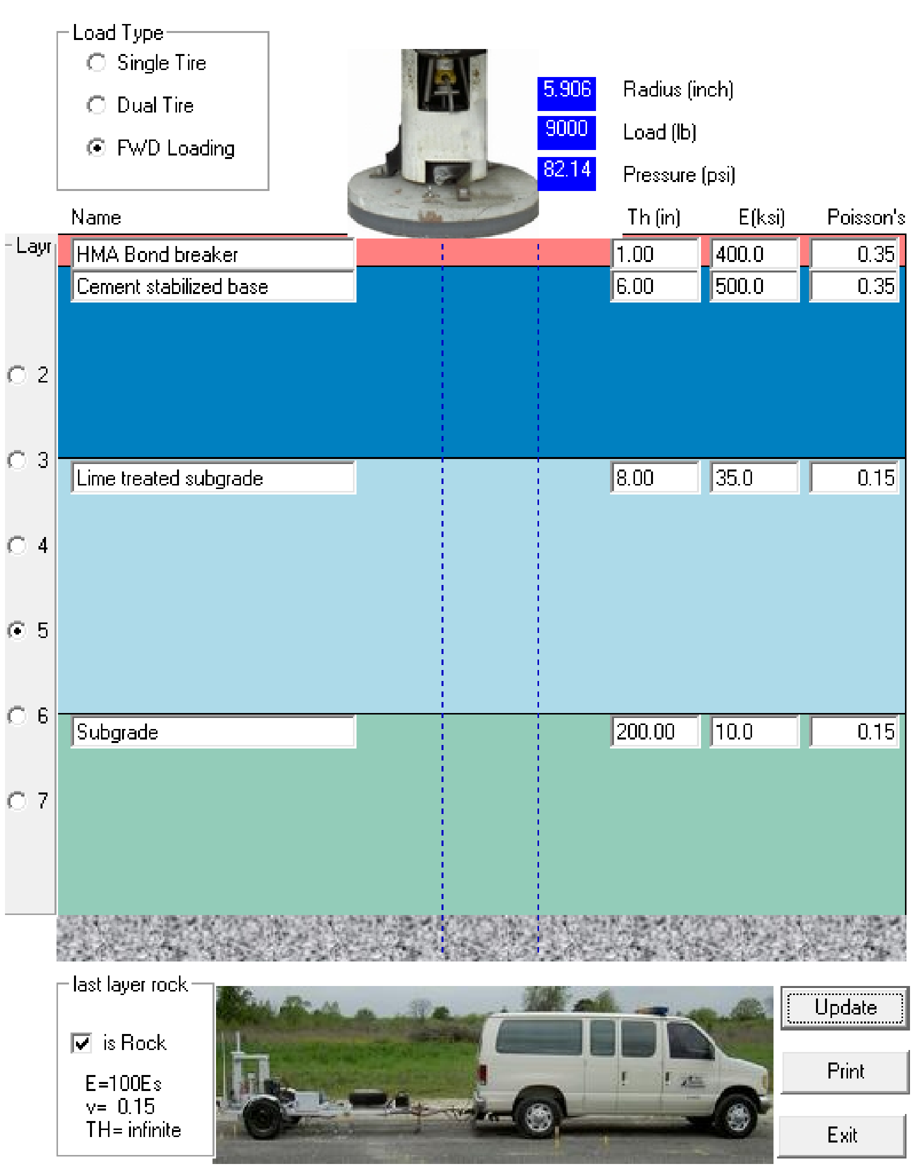


Pavement Stress Analysis Result

Location	ε_t	ε_v	σ_t	σ_v
Unit	(micro strain)		(psi)	
Btm of HMA	298.00	-375.00	165.00	-34.80
	224.00	-190.00	103.00	-20.30
Btm of Lime trea	317.00	-509.00	12.00	-9.41
	276.00	-395.00	9.77	-7.62
Top of Subgrade	317.00	-1000.00	2.06	-9.41
	276.00	-807.00	1.80	-7.62

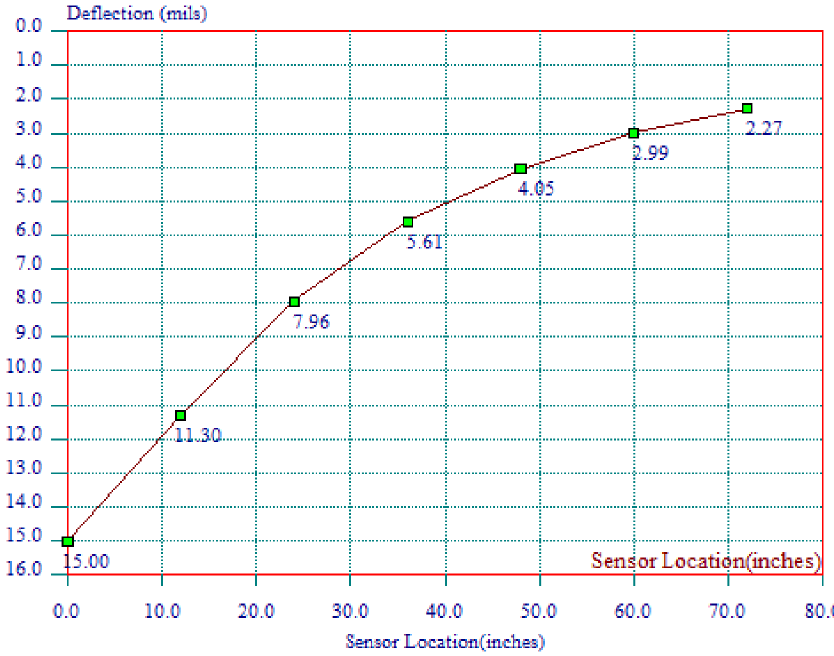


CSB/Bond breaker Base + LTS FWD deflections: 15 mils



Pavement Stress Analysis Result

Location	ε_t	ε_v	σ_t	σ_v
Unit	(micro strain)		(psi)	
Btm of HMA Bond	-107.00	-9.77	-109.00	-79.90
	-71.30	25.30	-66.50	-37.90
Btm of Cement st	161.00	-192.00	116.00	-15.30
	129.00	-122.00	82.60	-10.30
Btm of Lime trea	165.00	-188.00	5.92	-4.81
	151.00	-163.00	5.32	-4.22
Top of Subgrade	165.00	-513.00	1.09	-4.81
	151.00	-449.00	0.99	-4.22



Improved Pavement Quality with CTB

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Benefits of FDR with Cement

- Increased rigidity spreads the loads
- Eliminates rutting below the surface
- Reduced moisture susceptibility
- Reduced fatigue cracking in asphalt surfacing
- Allows for thinner pavement sections

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Ingredients

Materials in FDR with Cement Bases

FDR with cement bases are an intimate mixture of recycled asphalt pavement, graded aggregate base, and/or native soils with measured amounts of Portland cement and water that harden after compaction and curing to form a strong, durable, water- and frost-resistant pavement material.

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Materials that Can be Cement-Stabilized

- Sand
- Silt
- Clay
- Gravel
- Shell
- Crushed stone
- Slag
- Recycled HMA
- Recycled concrete

What is Cement Treated Base (CTB)?

- Highly compacted mixture of
  - Aggregate
  - Portland cement
  - Water
- Dense-graded (usually)
- Plant mixed or mixed in place
- Base material for
  - Flexible pavements (asphalt or chip seal surface)
  - Concrete pavements

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CTB Uses Variety of Aggregates

- Sand
- Gravel
- Caliche
- Crushed limestone (flex base)
- Recycled materials
  - Asphalt millings/RAP
  - Crushed concrete

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Why Consider CTB?

- Strongest, most resilient base available
  - High resilient modulus
  - Highly moisture resistant
  - Resists erosion
  - Resists settling
  - Spreads loads to weak subgrades
- Makes use of available local materials
- Less expensive to use the local materials

Evaluation of Stabilizer Type

Material Type - Including RAP	Well Graded Gravel	Poorly Graded Gravel	Silty Gravel	Clayey Gravel	Well Graded Sand	Poorly Graded Sand	Silty Sand	Clayey Sand	Silt, Silt with Sand	Lean Clay	Organic Silt/Organic Lean Clay	Elastic Silt	Fat Clay, Fat Clay with Sand
USCS[2]	GW	GP	GM	GC	SW	SP	SM	SC	ML	CL	OL	MH	CH
AASHTO[3]	A-1-a	A-1-a	A-1-b	A-1-b A-2-6	A-1-b	A-3 or A-1-b	A-2-4 or A-2-5	A-2-6 or A-2-7	A-4 or A-5	A-6	A-4	A-5 or A-7-5	A-7-6
Emulsified Asphalt SE > ... P_{200} ...													
Foa... PI < ... P_{200} ...													
Cem... Self... Clas... PI < ... SO_4 < 3000 ppm													
Lime/LKD PI > 20 and P_{200} > 25% SO_4 < 3000 ppm								X		X		X	X

“Portland Cement is probably the closest thing we have to a universal stabilizer.”

From U.S. Army Corps of Engineers report “*Chemical Stabilization Technology for Cold Weather*”, Sept. 2002

From ARRA *Basic Asphalt Recycling Manual*, 2015

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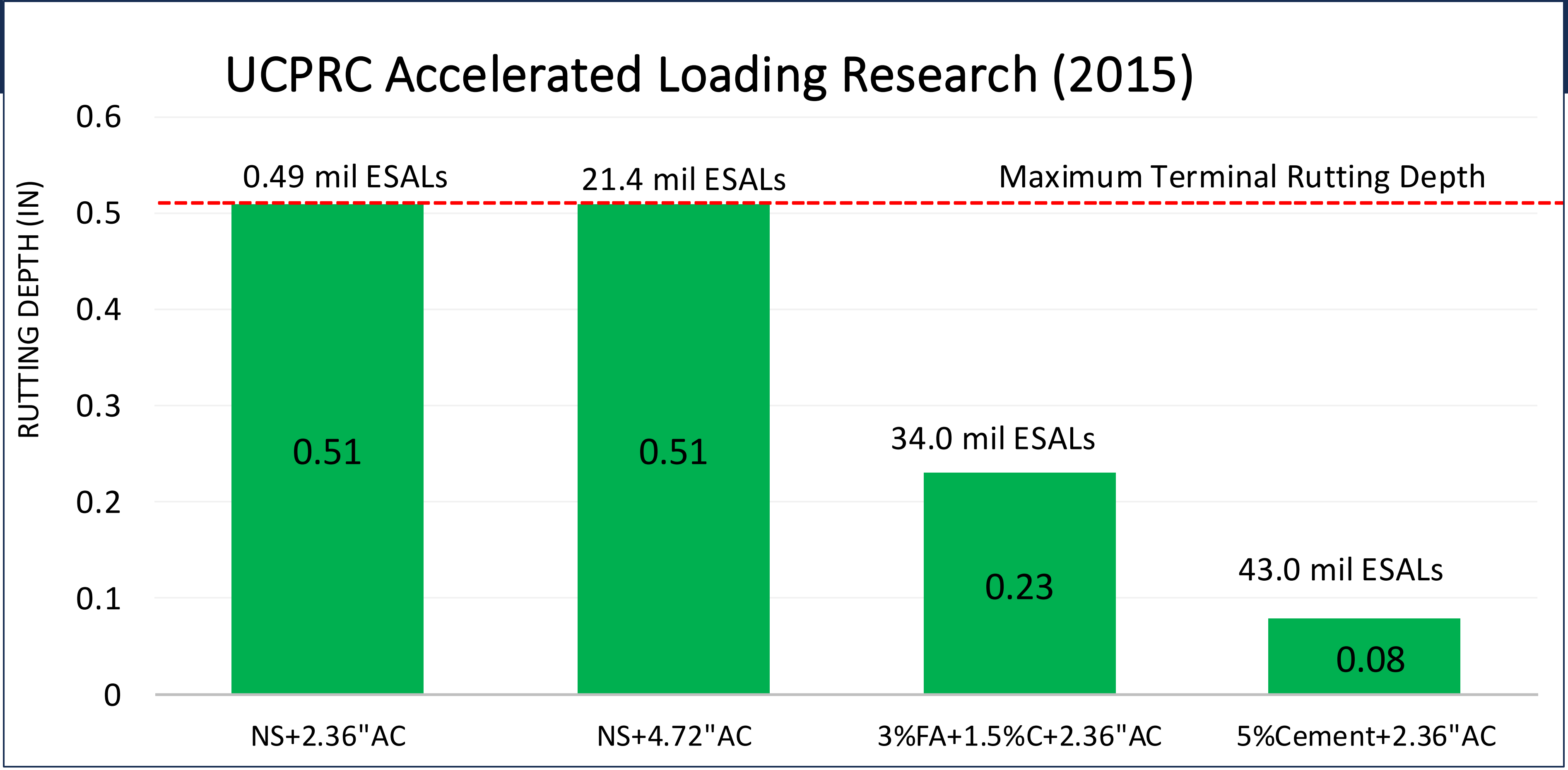
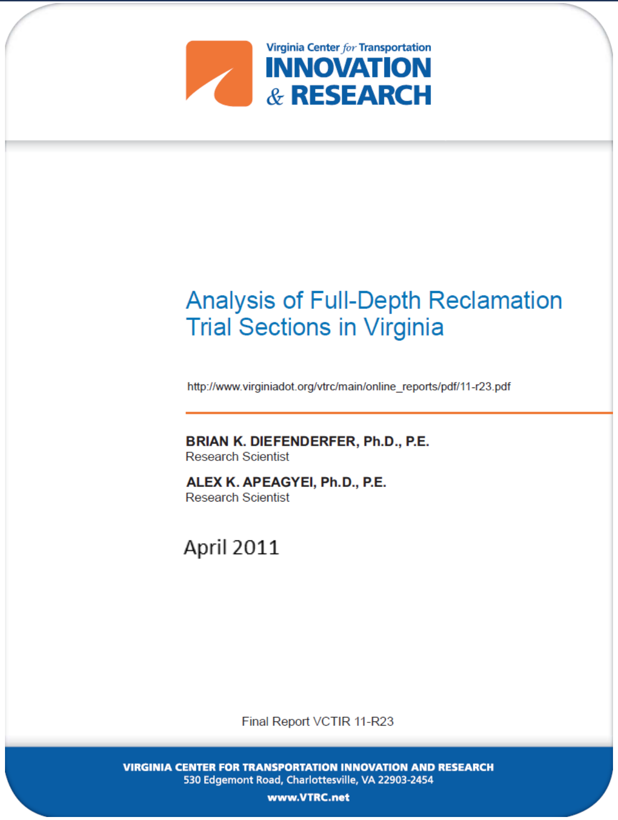
Comparing Different FDR Methods



Virginia DOT Study on FDR

- Stabilizers Tested:
  - Asphalt emulsion, foamed asphalt, Portland cement
- Calculated layer coefficients
  - Asphalt emulsion: 0.12 - 0.29
  - Foamed asphalt: 0.18 – 0.33
  - Portland cement: 0.24 – 0.34
- VDOT potential savings $463K to $1.42M per year with FDR


Virginia Center for Transportation
INNOVATION
& RESEARCH

Analysis of Full-Depth Reclamation Trial Sections in Virginia

http://www.virginiadot.org/vtrc/main/online_reports/pdf/11-r23.pdf

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April 2011

Final Report VCTIR 11-R23

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www.VTRC.net

www.virginiadot.org/vtrc/main/online_reports/pdf/11-r23.pdf

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Determining Cement Content

- Compressive strength (ASTM D1633)
  - Primary test for non-clay soils
  - 150 to 200 psi is generally adequate for CSS
  - 300 to 500 psi is sufficient for CTB
  - Select three cement levels, produce standard proctor cylinders at optimum moisture
  - Test compressive strength, determine cement content required for target strength
- PI reduction (ASTM D4318)
  - Primary test for clay/expansive soils
  - Reduce to PI < 15 or 20 generally adequate for CSS
  - Select three cement levels, perform Atterberg limits tests
  - Select cement (or lime for high existing PI) level required for target PI

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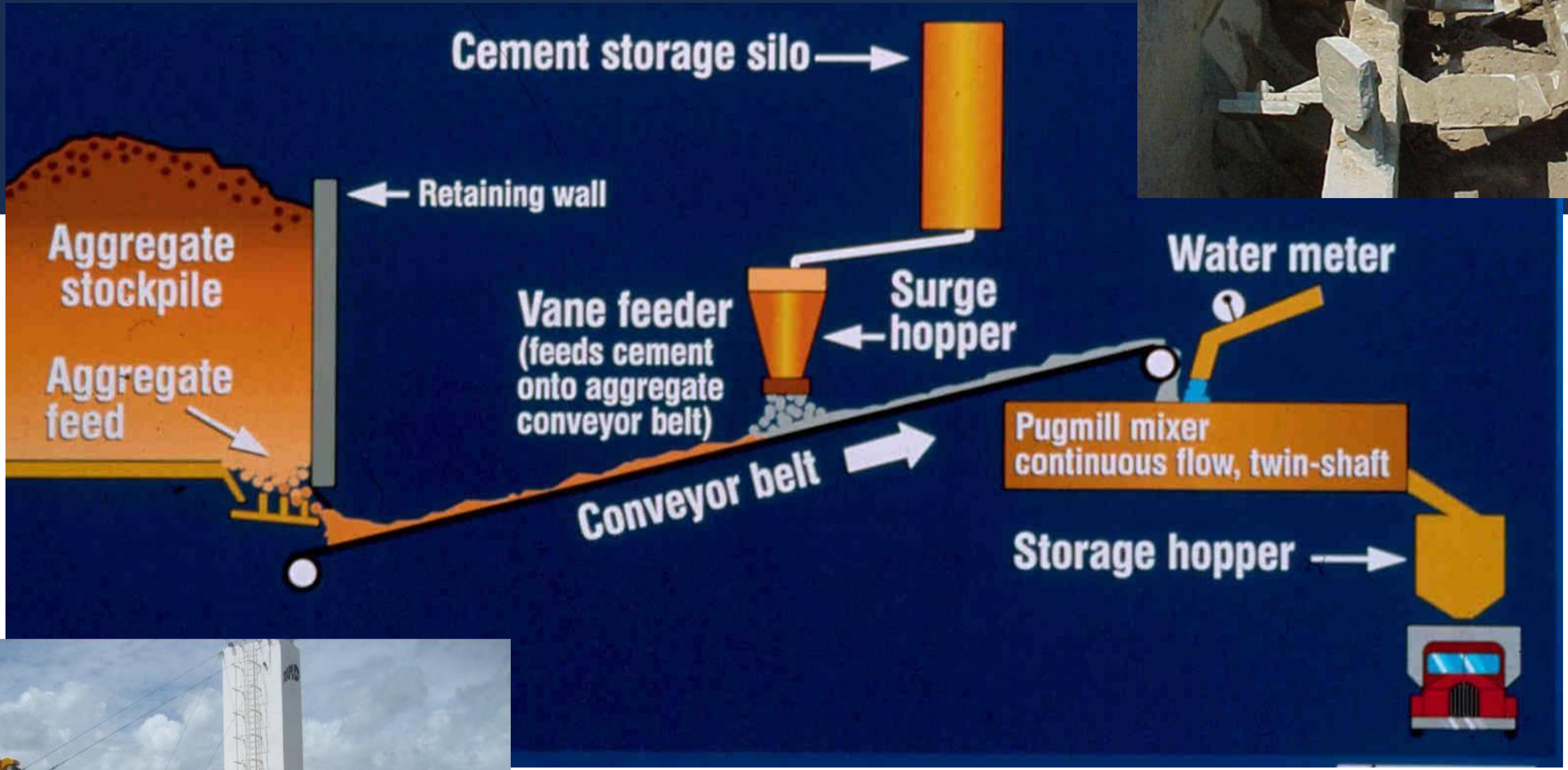
Don’t Over-Stabilize

Construction

Plant-Mixed CTB



Construction

- **Construction Process**
  - Moisture Conditioning (If Necessary)
  - Initial Pulverization (If Necessary)
  - Preliminary Grading
  - Cement Application
  - Mixing
  - Optimum Moisture Content
  - Compaction
  - Final Grading
  - Curing

Photo credit: Corey Zollinger

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Construction (cont.)

- **Construction Equipment**
  - Cement or slurry spreader/distributor truck
  - Reclaimer/mixer
  - Water truck
  - Grader
  - Tamping/sheepsfoot/padfoot roller (for clayey and sil
  - Smooth drum roller (for granular soils)
  - Pneumatic tire roller (optional)

Images: Virginia DOT

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Construction (cont.)

Bulk Cement
- Lowest Cost
- Dusty

Slurry Cement
- Solves dust problem
- Increased Cost

Slurry Train – Slurry injected into mixing chamber

Spreader Trucks

Slide credit: Corey Zollinger

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Full Depth Reclamation with Cement

- Pulverize the roadbed materials
- Blade to desired roadway template
- Spread cement either dry or as a slurry
- Mix all materials directly on the roadbed
- Bring to optimum moisture content
- Compact to 98% standard Proctor
- Shape the roadway to Plan requirements

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Cement Spread Requirements

Percent cement by weight		Percent cement by volume	Cement spread requirements in pounds per square yard (kg/m²) for compacted thicknesses				
100 pcf (1602 kg/m³)	110 pcf (1762 kg/m³)		5 inches (125 mm)	6 inches (150 mm)	7 inches (175 mm)	8 inches (200 mm)	9 inches (225 mm)
1.9	1.7	2.0	7.1 (3.8)	8.5 (4.6)	9.9 (5.4)	11.3 (6.1)	12.7 (6.9)
2.4	2.1	2.5	8.8 (4.8)	10.6 (5.7)	12.3 (6.7)	14.1 (7.6)	15.9 (8.6)
2.8	2.6	3.0	10.6 (5.7)	12.7 (6.9)	14.8 (8.0)	16.9 (9.2)	19.0 (10.3)
3.3	3.0	3.5	12.3 (6.7)	14.8 (8.0)	17.3 (9.4)	19.7 (10.7)	22.2 (12.0)
3.8	3.4	4.0	14.1 (7.6)	16.9 (9.2)	19.7 (10.7)	22.6 (12.2)	25.4 (13.8)
4.2	3.8	4.5	15.9 (8.6)	19.0 (10.3)	22.2 (12.0)	25.4 (13.8)	28.6 (15.5)
4.7	4.3	5.0	17.6 (9.6)	21.2 (11.5)	24.7 (13.4)	28.2 (15.3)	31.7 (17.2)
5.2	4.7	5.5	19.4 (10.5)	23.3 (12.6)	27.1 (14.7)	31.0 (16.8)	34.9 (18.9)
5.6	5.1	6.0	21.1 (11.5)	25.4 (13.8)	29.6 (16.1)	33.8 (18.4)	38.1 (20.7)
6.1	5.6	6.5	22.9 (12.4)	27.5 (14.9)	32.1 (17.4)	36.7 (19.9)	41.2 (22.4)
6.6	6.0	7.0	24.7 (13.4)	29.6 (16.1)	34.5 (18.7)	39.5 (21.4)	44.4 (24.1)

Source: Guide to Cement-Modified Soil (PCA, EB242)

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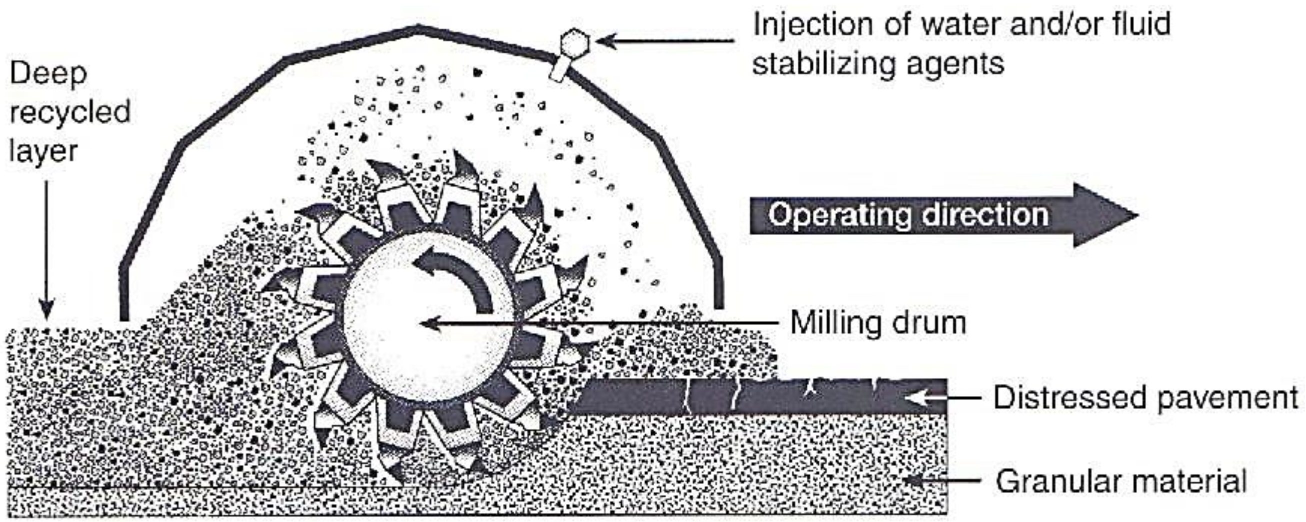
Inside a Reclaimer



Compaction and Grading

Material is compacted to 96 to 98 percent minimum standard proctor density and then graded to appropriate lines, grades, and cross- sections.

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Curing

- Bituminous Compounds (cutbacks or emulsions)

- Water (kept continuously moist)

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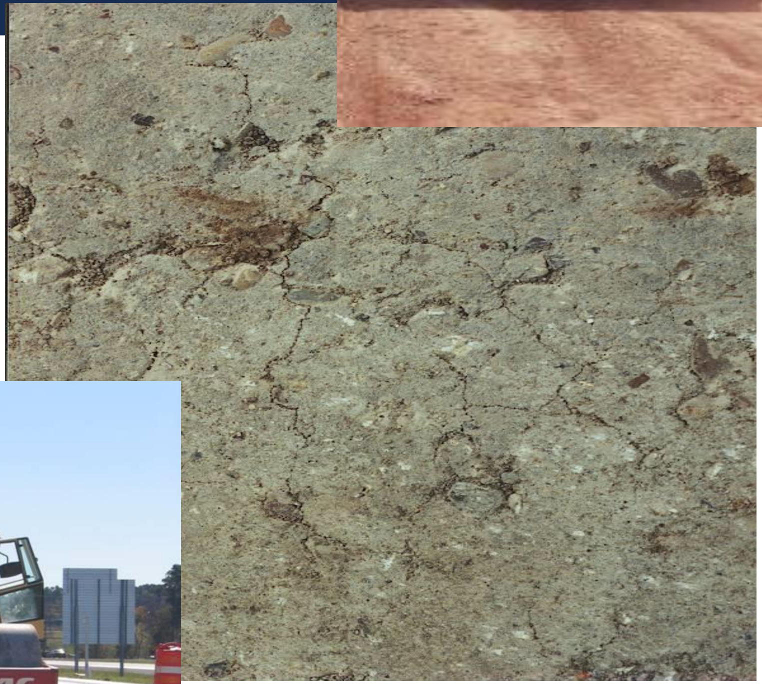
Microcracking Procedure



- 10-to-12-ton vibratory roller
- 24 to 48 hours after placement
- Creep speed
- High amplitude
- Typically, 3 passes

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Ottinger Road – Tarrant County Microcracked Section

Projects

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Who Is Using It In Texas? (Partial List)

- Goliad County
- Bell County
- Bexar County
- Grand Prairie
- City of Ft Worth
- Tarrant County
- Port of Houston
- Town of Navasota

- Lubbock District
- Corpus Christi District
- Bryan District
- San Antonio District
- Fort Worth District
- Houston District
- Beaumont District

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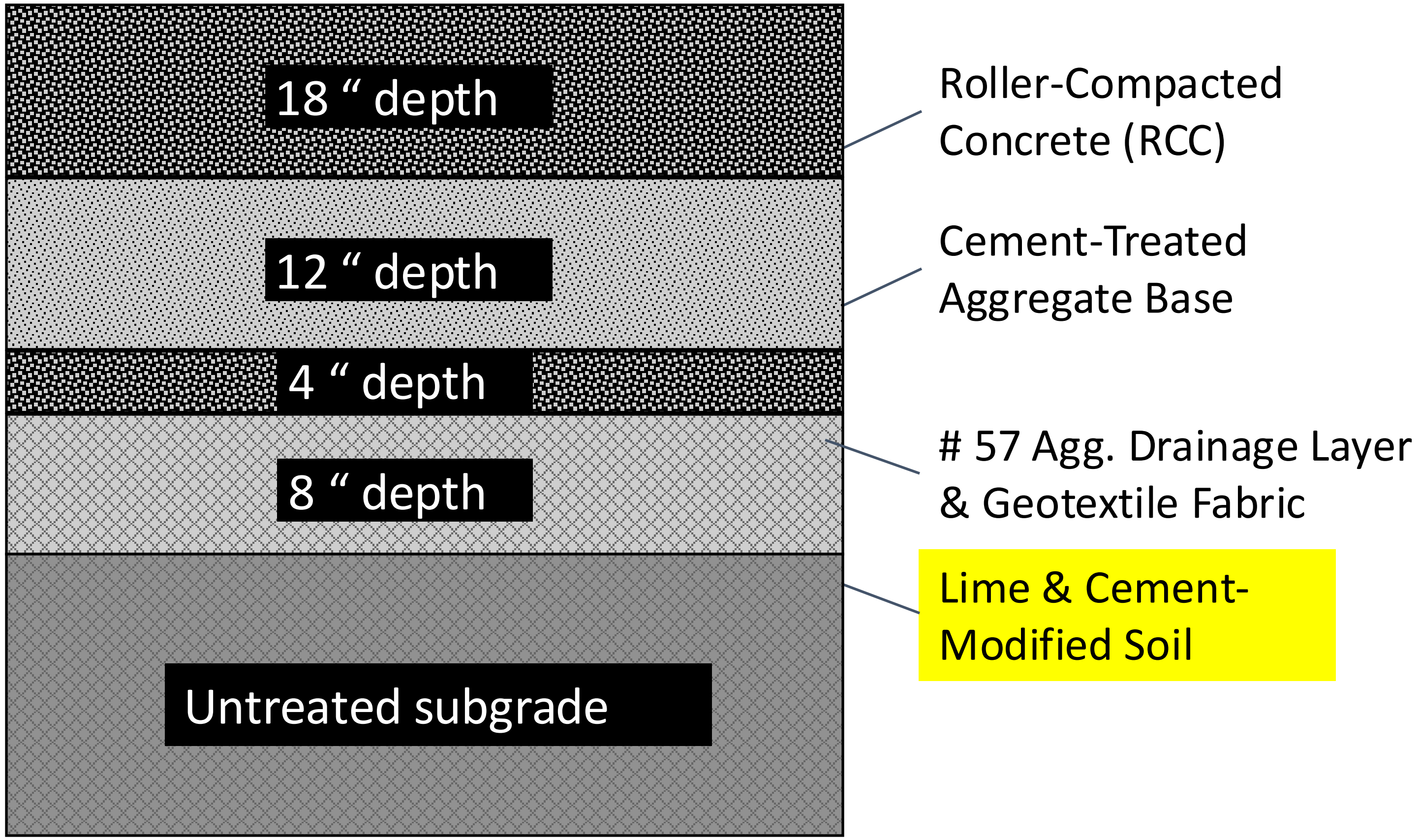
Port Houston Bayport Terminal



Lime plus Cement Projects

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TxDOT Pharr District
UP281 in Rio Grande Valley

- Used 6% Lime + 2% Cement
- Added Cement because 6% lime alone did not stabilize or add significant strength to the to the subgrade
- For this reason, UCS test should not be waived when using lime alone

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TxDOT Waco District
IH 35E in Hill County

- Using Lime + Cement
- Using the combination because of the varying soil types encountered on the project
- Recently other parts IH 35 in had significant heave using soil replacement with select fill
- It is suspected that insufficient depth of replacement and existing subgrade pressure may have contributed to the problems in southern Hill County.

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City of Arlington

- In 2008 and 2009 Dr. Puppala from UTA studied 3 roads using the combination of Lime + Cement for road base-soil mixture
- Lab analysis was performed using 4% Lime and 4% Cement
- Road work and field samples were performed using 6% lime and 6% cement
- City is happy with the process and is using this stabilization method under concrete pavement without a bond breaker

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Tarrant County

- Reclamation of road base-soil mixture below milled asphalt surfaces
- Typically using 4% lime
- Then adding 4% cement the next day
- Confirming additive percentages with laboratory testing
- Able to allow local traffic the next day

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Summary

Why CSS or CTB?

- Cement factors of 2 to 8% (3 to 5% common)
- Effective in granular and clay soils
- Significant and immediate reductions in PI
- Immediate increases in soil strength
  - Next-day or same day traffic and construction (no “mellowing”)
  - All-weather work platform
- Produces workable foundation for both rigid and flexible pavements
- Permanent modification:
  - Strength improves immediately and increases over years
  - No long-term effects from leaching
- Save cost

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QUESTIONS?