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HARD CORE
A Zoned Embankment Case Study

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Geo 3T2
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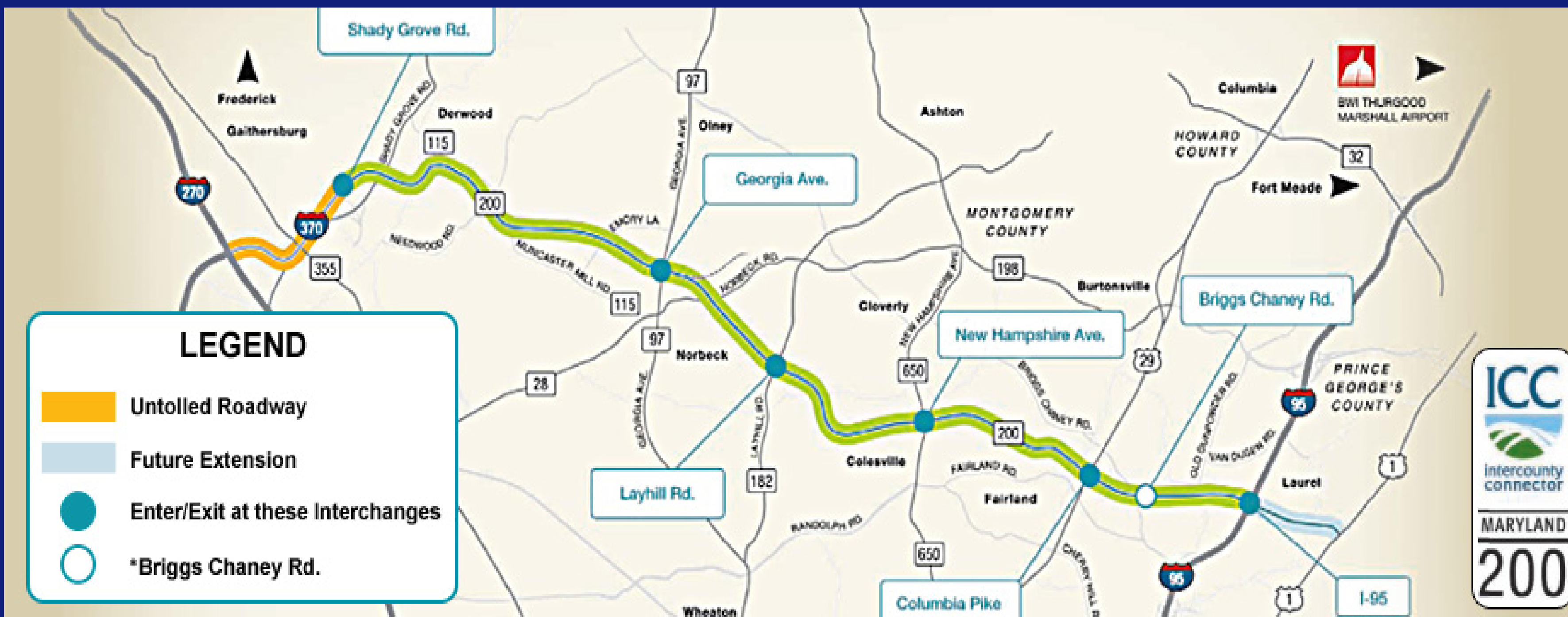
Zoned Embankment Overview

- Introduction
- Problem
- Solution
- Analyses
- Results
- Other Methods
- Lessons Learned

Introduction

- 18.8 miles – I-270/I370 to I-95/US-1
- 6-lane divided highway with 8 full interchanges



*Drivers can access eastbound ICC from Briggs Chaney Road. Briggs Chaney Road may only be accessed from westbound ICC.

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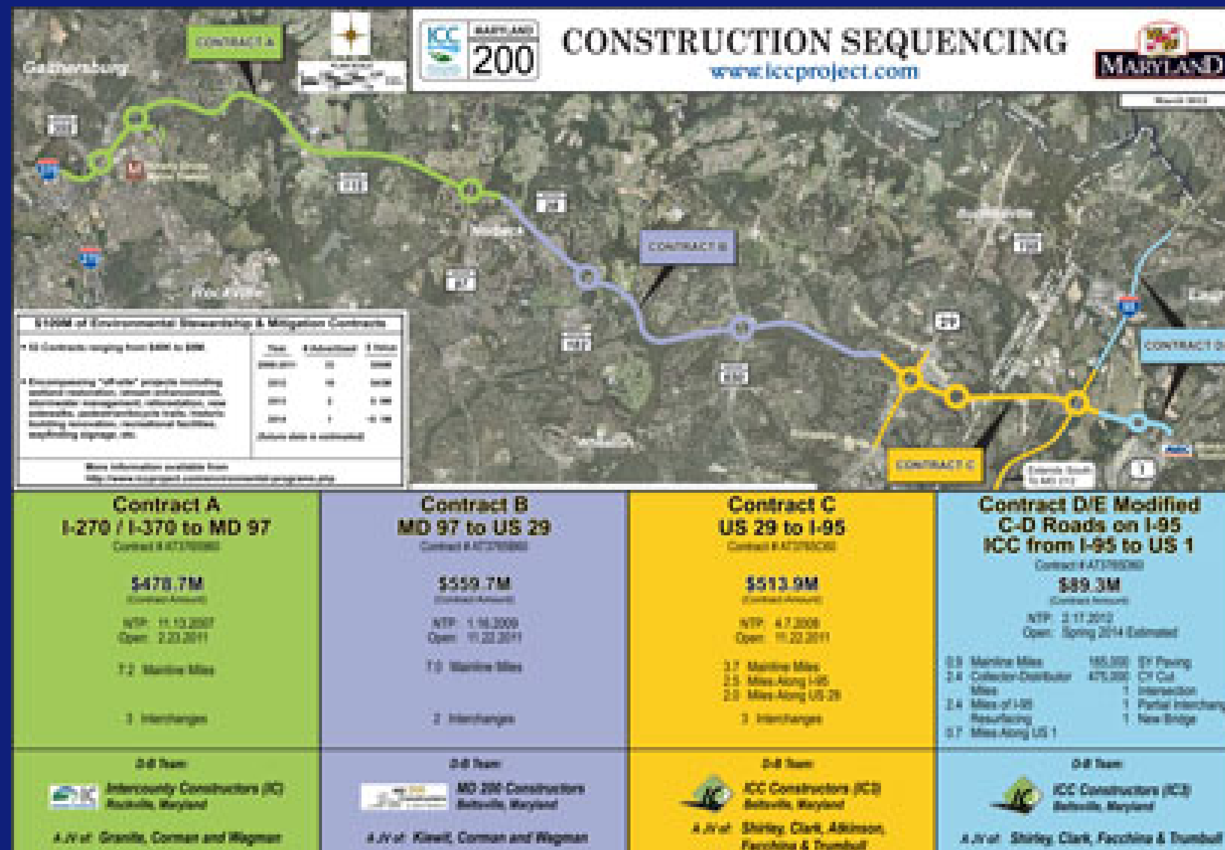
Introduction

- Purpose:
  - Link existing and proposed development
  - State-of-the-art, limited/controlled access
  - Minimal environmental impact



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Problem - Earthwork Conditions

Fill Requirement: 92% MDD (Modified) at +/- 2% OMC

- Average natural moisture content of on-site soils 4% above optimum
- Year-round fill placement with rainy season
- 35 ft tall embankments
- Piedmont Residual Soils
  - Silts, Silty Sands
  - LL = NP to 65, PI = NP to 30
  - NMC = 8% to 45% +
  - Max. Dry Density ~ 110 pcf
  - OMC ~ 12%

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Solution - Soil Cement

- Modification: Temporary
  - Reduces soil plasticity
  - Increases strength
- Stabilization: Permanent
  - Permanent strength increase
  - Increased resilient modulus
  - Reduce shrink/swell
  - Freeze/thaw resistance

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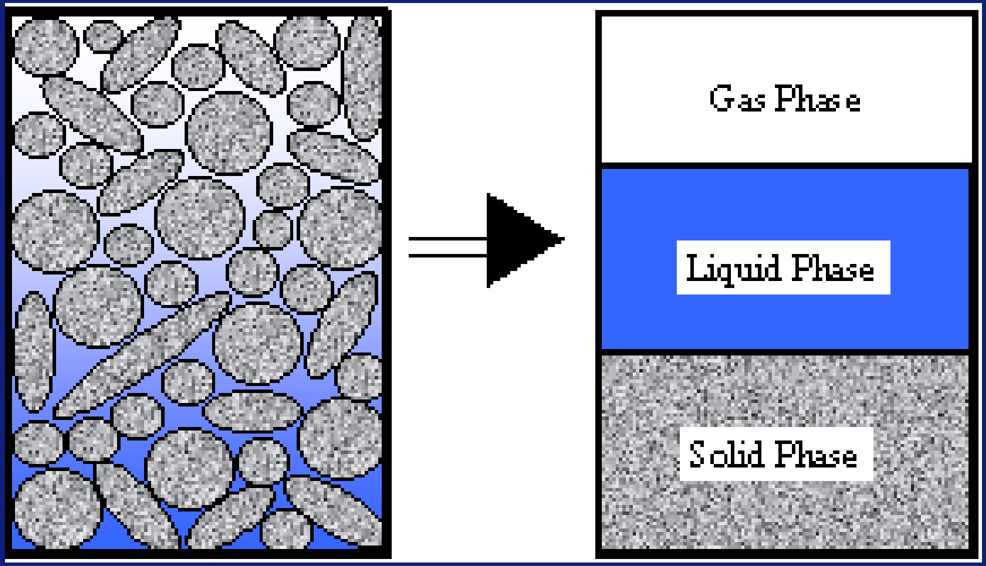
Solution - Soil Cement

- Most benefit in granular soils
- Formation of calcium silicate hydrate
- Dose depends on strength, durability, soil type

Why not Lime?



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Solution – Maryland SHA Concerns

- Pavement Subgrade
  - Performance
  - Durability
- Slope Stability
- Compressibility
- Leachate
- Landscaping

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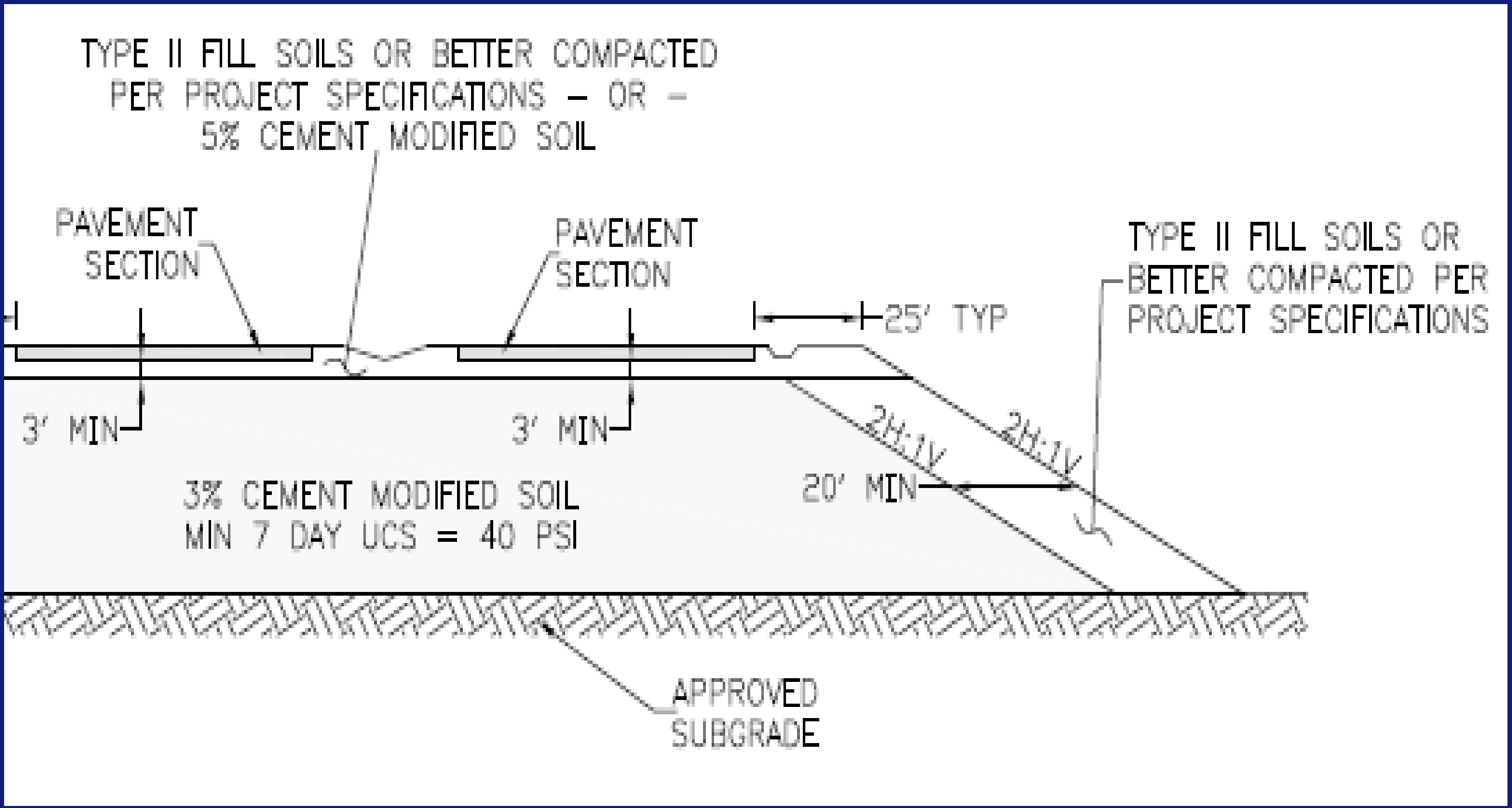
Solution – Zoned Embankment



Solution

- Zoned Embankment Concept

Add cement to core soils:

- Reduce compacted fill density while:
  - Achieving soil strength
  - Reducing compressibility
- Modify soil index properties
  - Reduce plasticity
  - Improve workability
- Allow fill placement at high moisture contents

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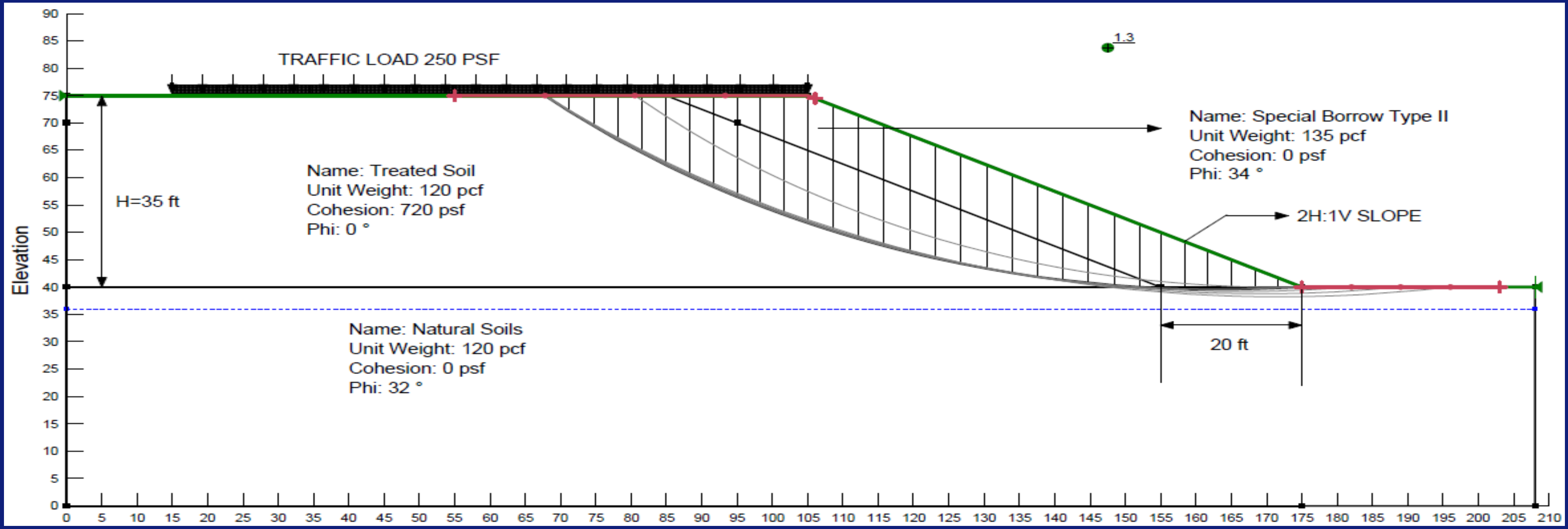
Analyses

- Slope stability
- Global embankment slope stability: FS>1.3
  - Cohesion = 720 psf
  - UCS > 10 psi



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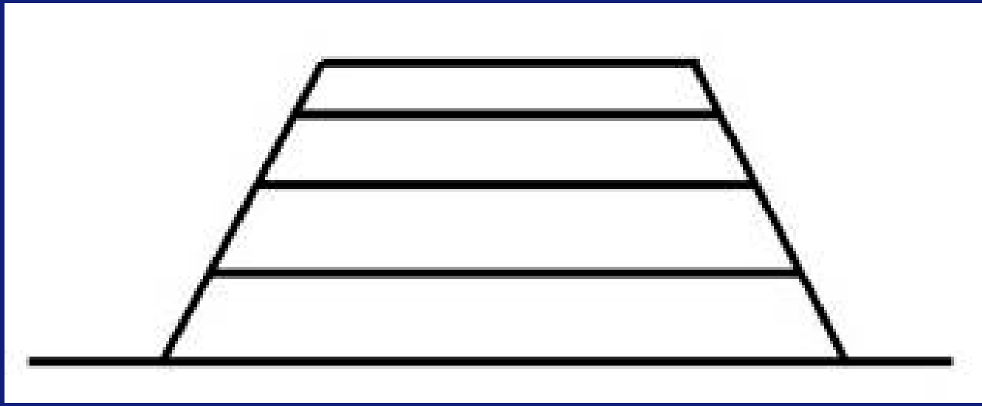
Analyses

- Embankment loads
  - Max embankment height of 35-ft, 32.5-ft to TOS
  - Max Overburden Pressure = 120 pcf*32.5 ft + 250 psf (traffic load) + 325 psf (pavement section) = 4,475 psf = 31 psi
  - 31 psi * 1.3 (FS) = 40 psi



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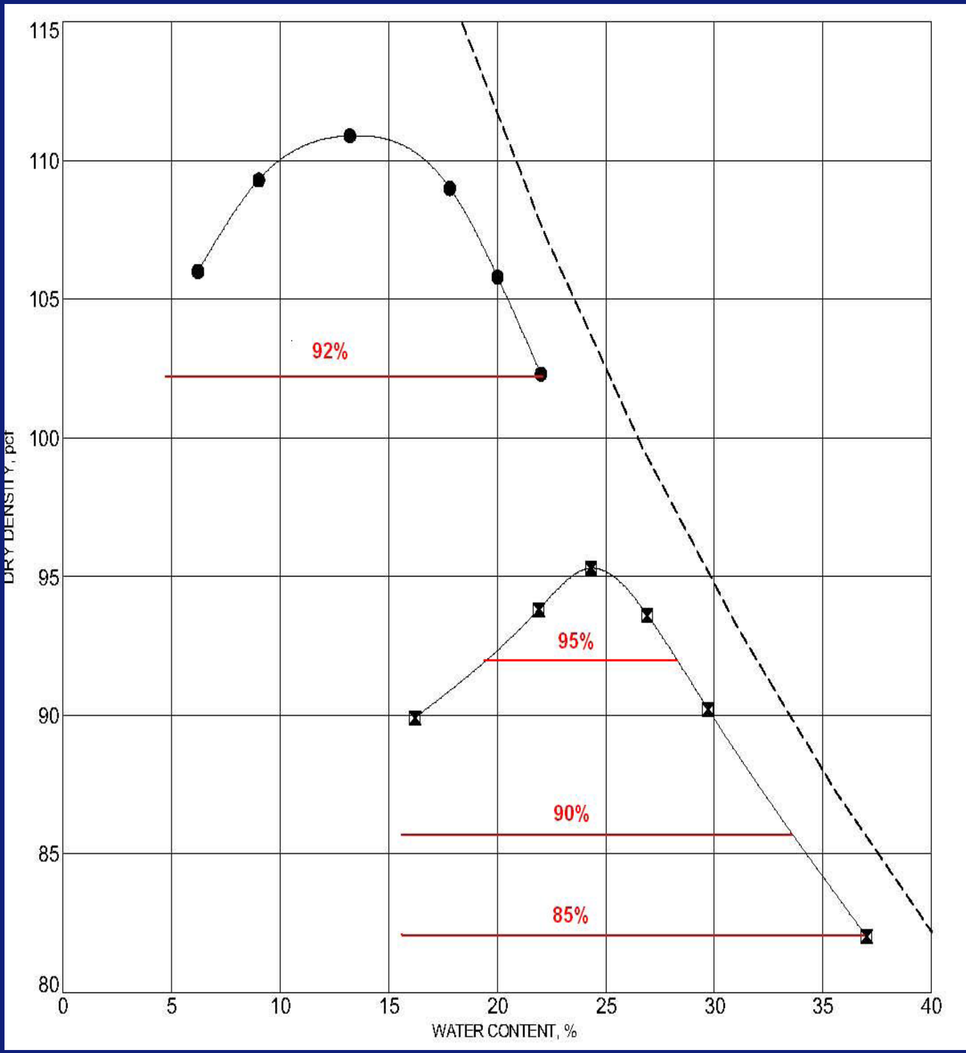
Results

- Laboratory tests
- Samples at 0, 3, 4, 6% Cement
  - Classification
  - Proctors (Std/Mod)
  - Unconfined Compression
    - Molded to 85, 90, 95% of Std, 92% of Mod
    - Wet as possible to achieve density
    - Cured 1, 7, 14, 28 days
  - Consolidation



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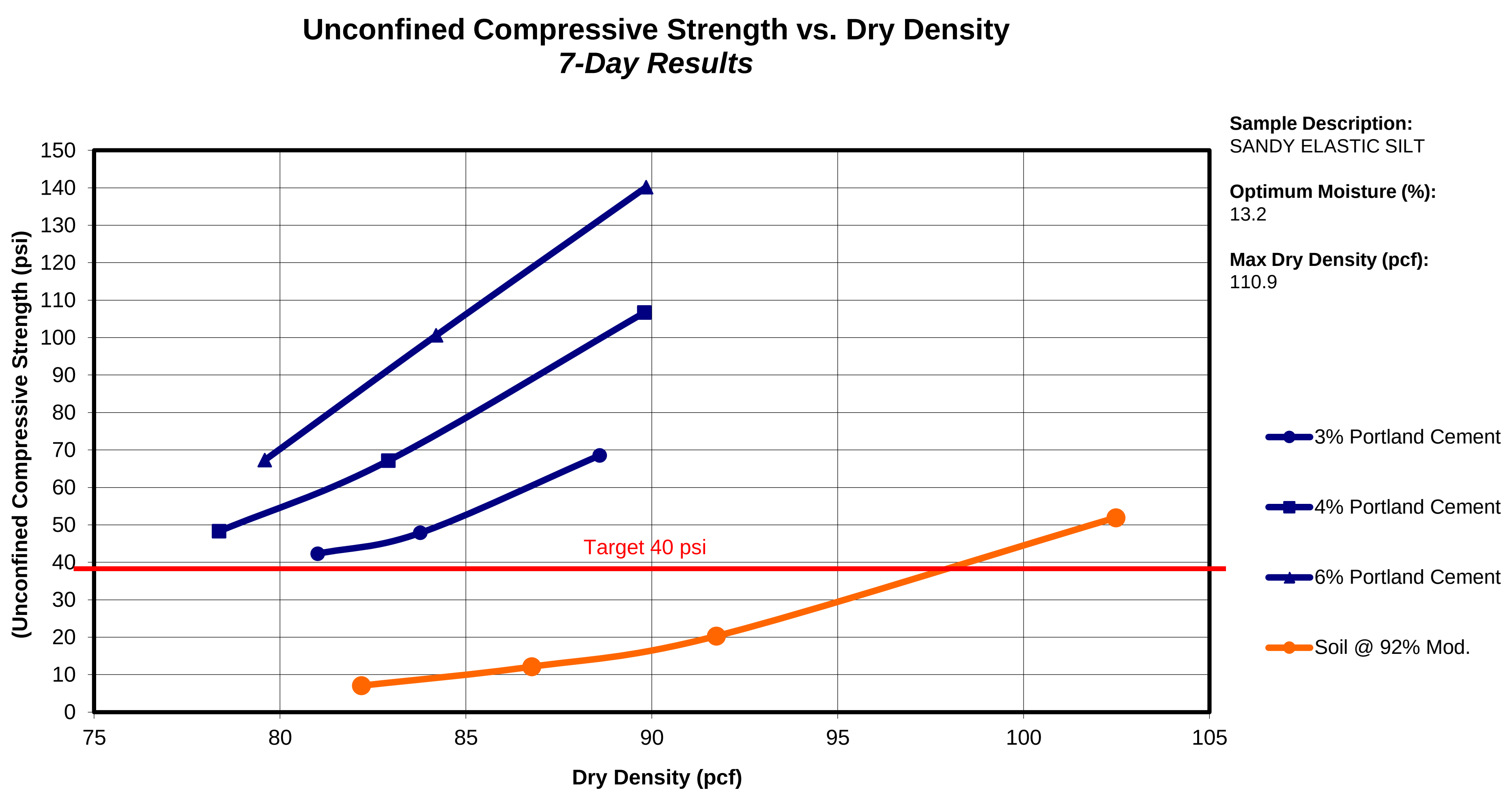
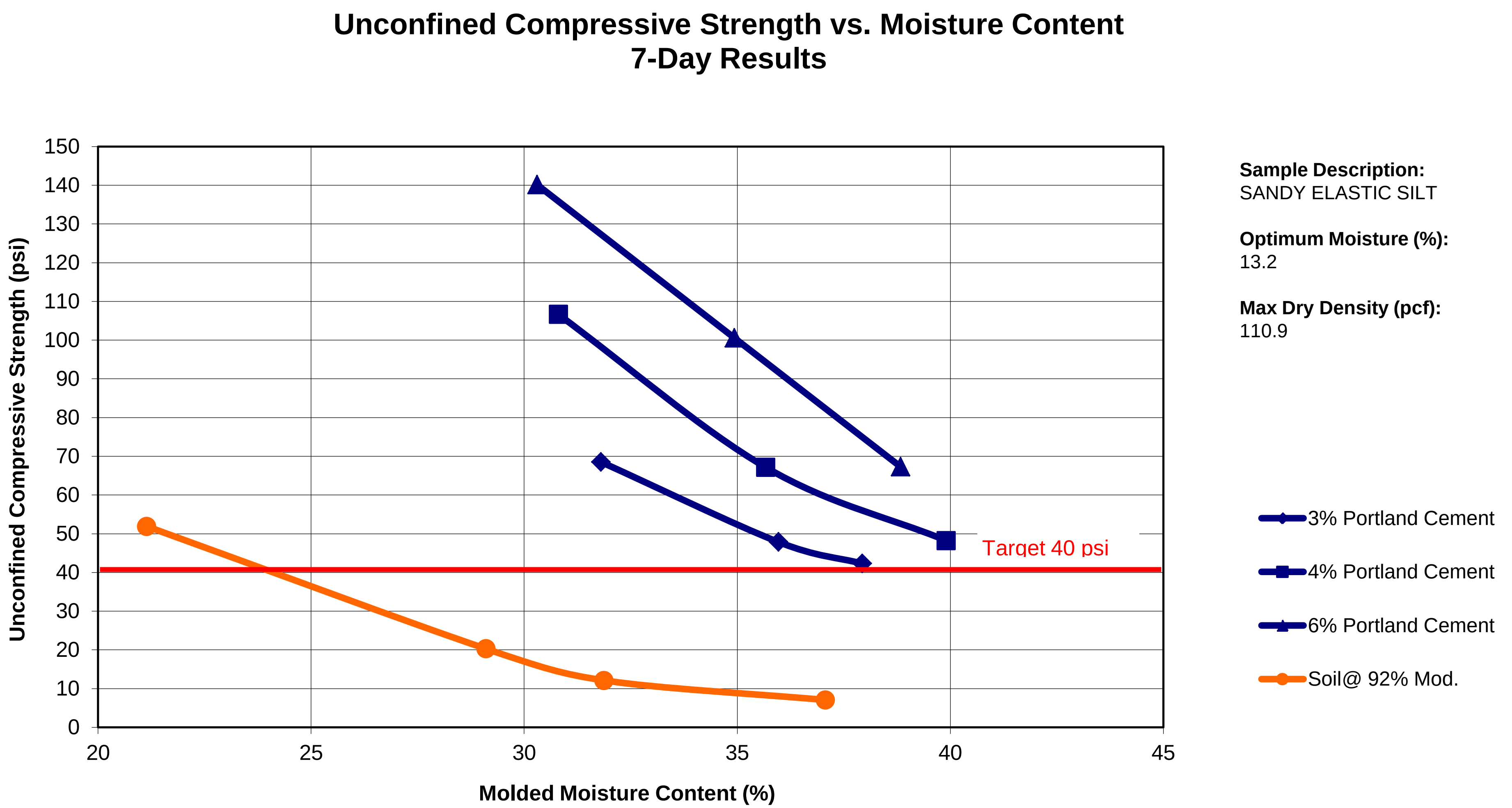
Results



Unconfined Compressive Strength vs. Dry Density
7-Day Results
Sample Description:
SANDY ELASTIC SILT
Optimum Moisture (%):
13.2
Max Dry Density (pcf):
110.9
(Unconfined Compressive Strength (psi)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
75
80
85
90
95
100
105
Dry Density (pcf)
Target 40 psi
3% Portland Cement
4% Portland Cement
6% Portland Cement
Soil @ 92% Mod.

Results



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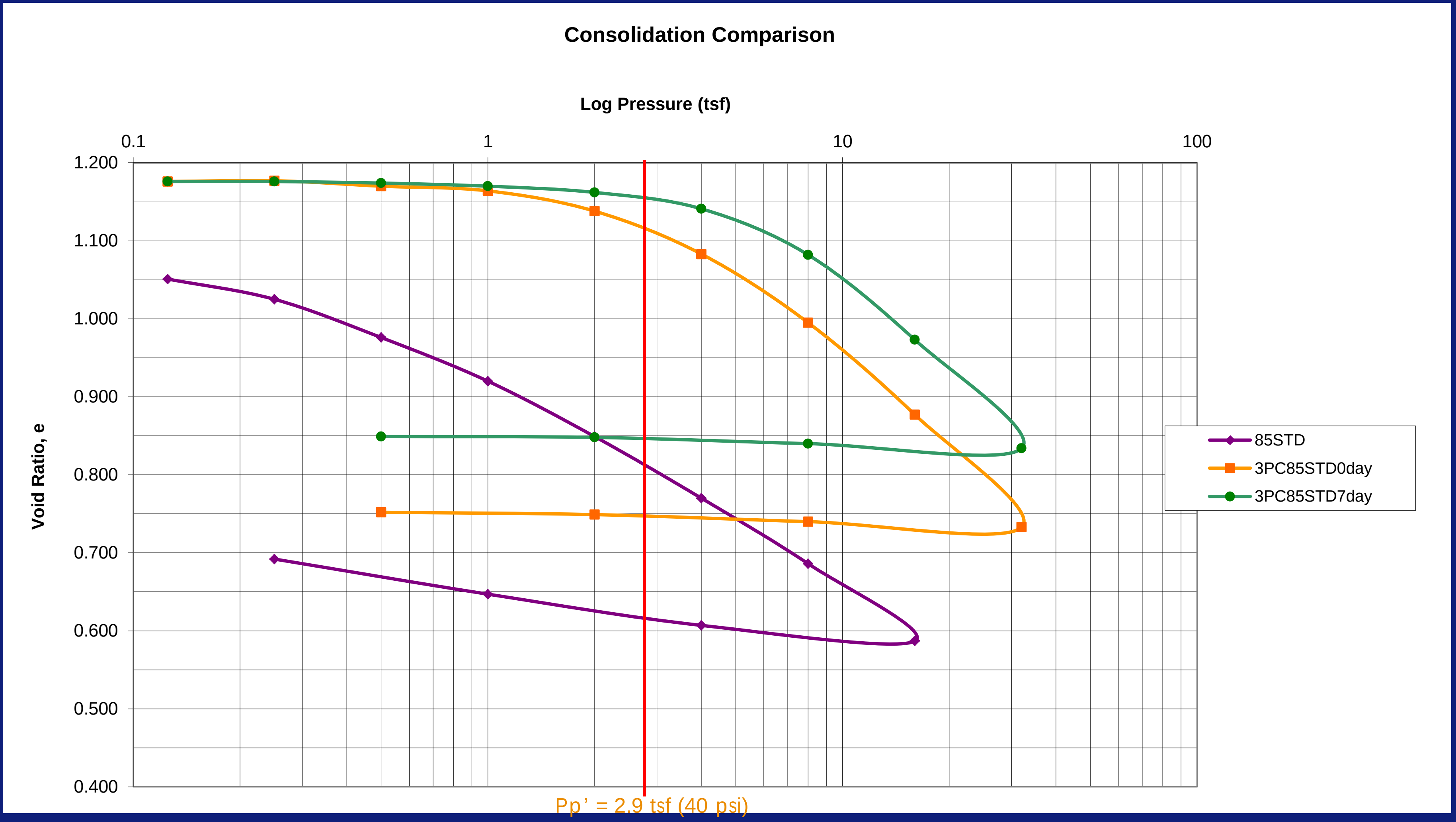

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Results – Field Procedures

- Zoned embankment
  - Cement dose of 3-percent
  - Compact to 85% MDD per AASHTO T-99
  - Dry density > 80 pcf
  - Moisture content < 40%
- Test strips
  - Establish effective construction methods
  - Establish QC tests
  - Verify core properties are achieved

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Results – Quality Control Procedures

- Visual observations
- Perform >10 nuclear density tests per lift/day
- Mold compressive strength test cylinders
  - +/- 2 pcf of lowest density recorded
  - Cure and compressive strength test at 7 days
  - UCS > 40 psi at 7 days

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Results

- Success!
  - Contractor could place fill year round
  - Met project schedule
  - Overall cost savings

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Other Methods - Compaction Based

- Contract B used an alternative method
  - Same 3% for embankment / 5% for pavement subgrade but eliminated the zone concept
  - If compaction criteria met, considered cement as modification only
  - If compaction criteria not met, utilized strength based approach
  - Transferred landscaping risks to subcontractor

This flexibility was valuable to the contractor

Due to increased durability and reliability, the contractor used soil cement even when not necessary

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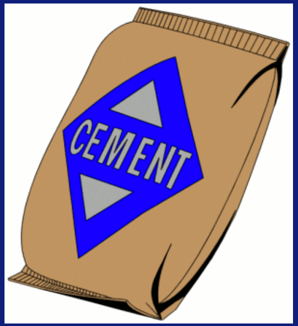
Lessons Learned

- Considering cement modification/stabilization is an investment and can be time consuming
- Cement can be useful at low doses
- The same cement used in laboratory study must be used in the field operations
- Field observations are critical to evaluation

The best Quality Control plans evaluate the work based on field observations and use laboratory testing to confirm field results



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Lessons Learned

- Feasibility Study, Operation Plan, and Quality Control Plan must be developed full circle
  - This can be a challenge
  - Consider broad Feasibility Study (broader study early means more options later)
  - Expect variations
  - Use a Factor of Safety to account for variability in field/lab methods

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QUESTIONS?

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