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HARD CORE
A Zoned Embankment Case Study

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STGEC
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Overview

- Introduction
- Soil Cement
- Problem
- Solution
- Analyses
- Results
- Lessons Learned

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Introduction

- 18.8 miles – I-270/I370 to I-95/US-1
- 6-lane divided highway
- 8 full interchanges
- 1 partial interchange
- Significant cut → fill
  - 6+ million cy

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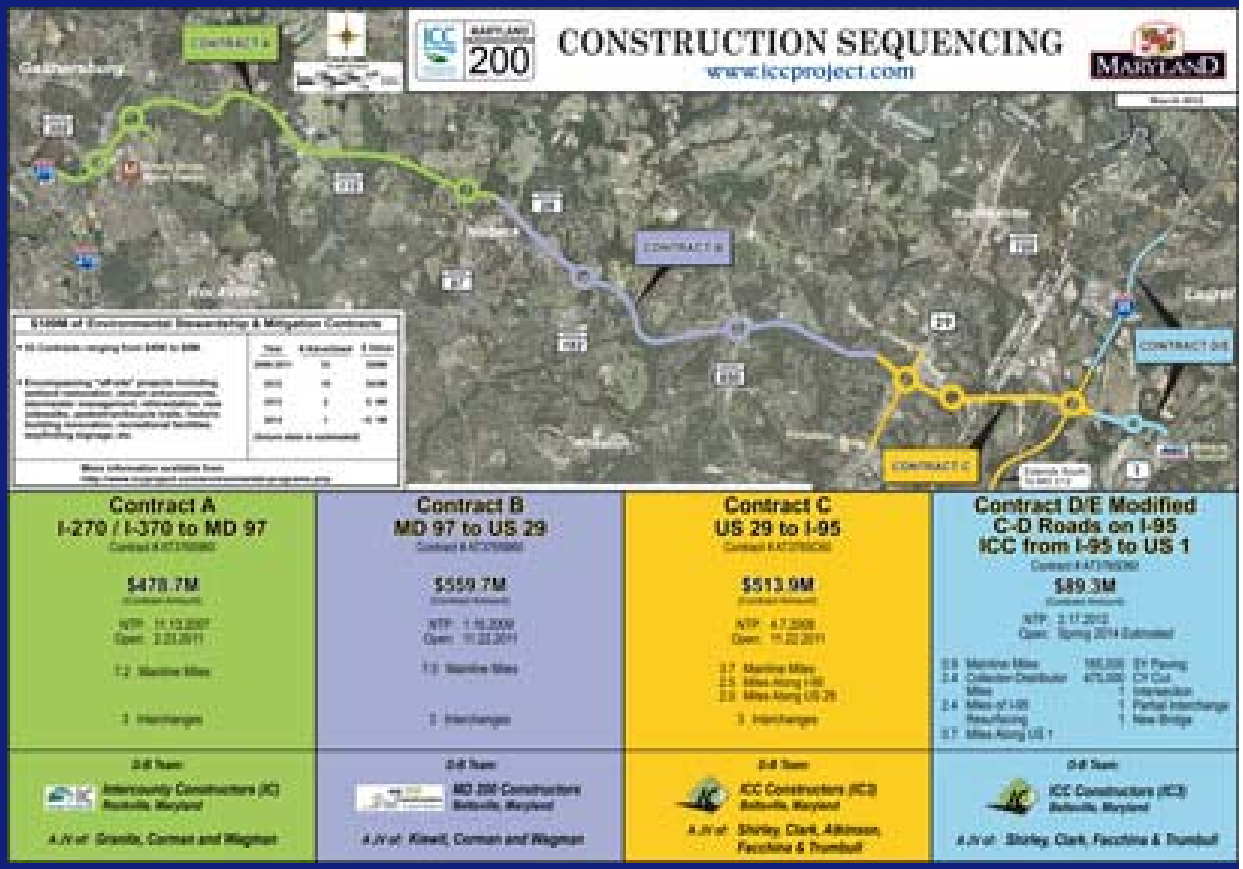
Introduction

- Purpose:
  - Link existing and proposed development
  - State-of-the-art, multi-modal, east-west, limited/controlled access
  - Move passengers and goods



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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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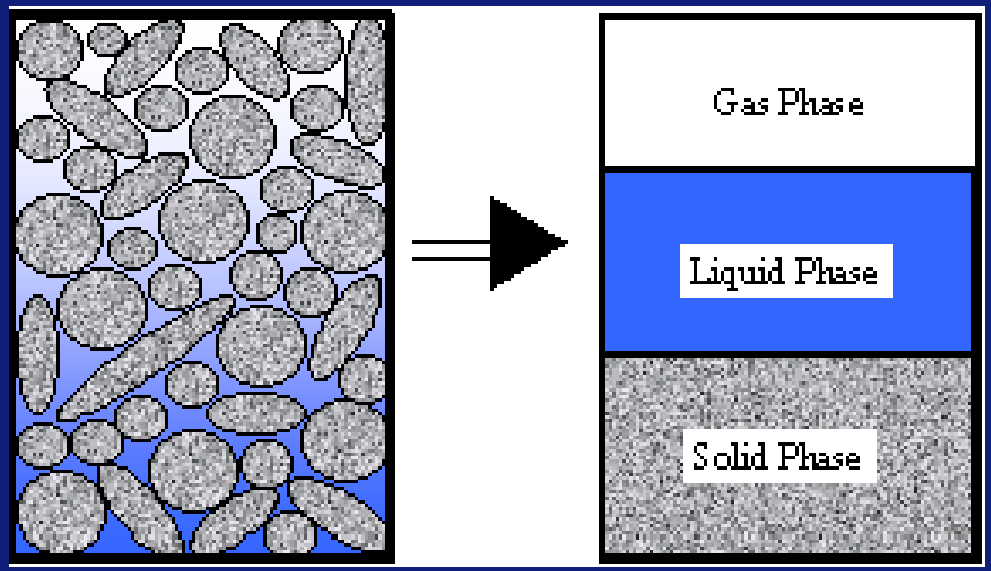
Soil Cement

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



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Problem

- Natural moisture content of half of site soils greater than optimum
- Year-round fill placement
- Embankments up to 35-ft high
- Silts, Silty Sands
  - LL = NP – 65
  - PI = NP – 30
  - Max. Dry Density = 110 pcf
  - OMC = 12%
  - NMC = 25 – 45% +

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Solution

- Zoned Embankment Concept – Team
- Schnabel to design core material
- Add cement to core soils:
  - Reduce compacted fill density while:
    - Achieving soil strength
    - Reducing compressibility
  - Modify soil index properties
    - Reduce plasticity
    - Improve workability
  - Allow placement at much higher moisture contents

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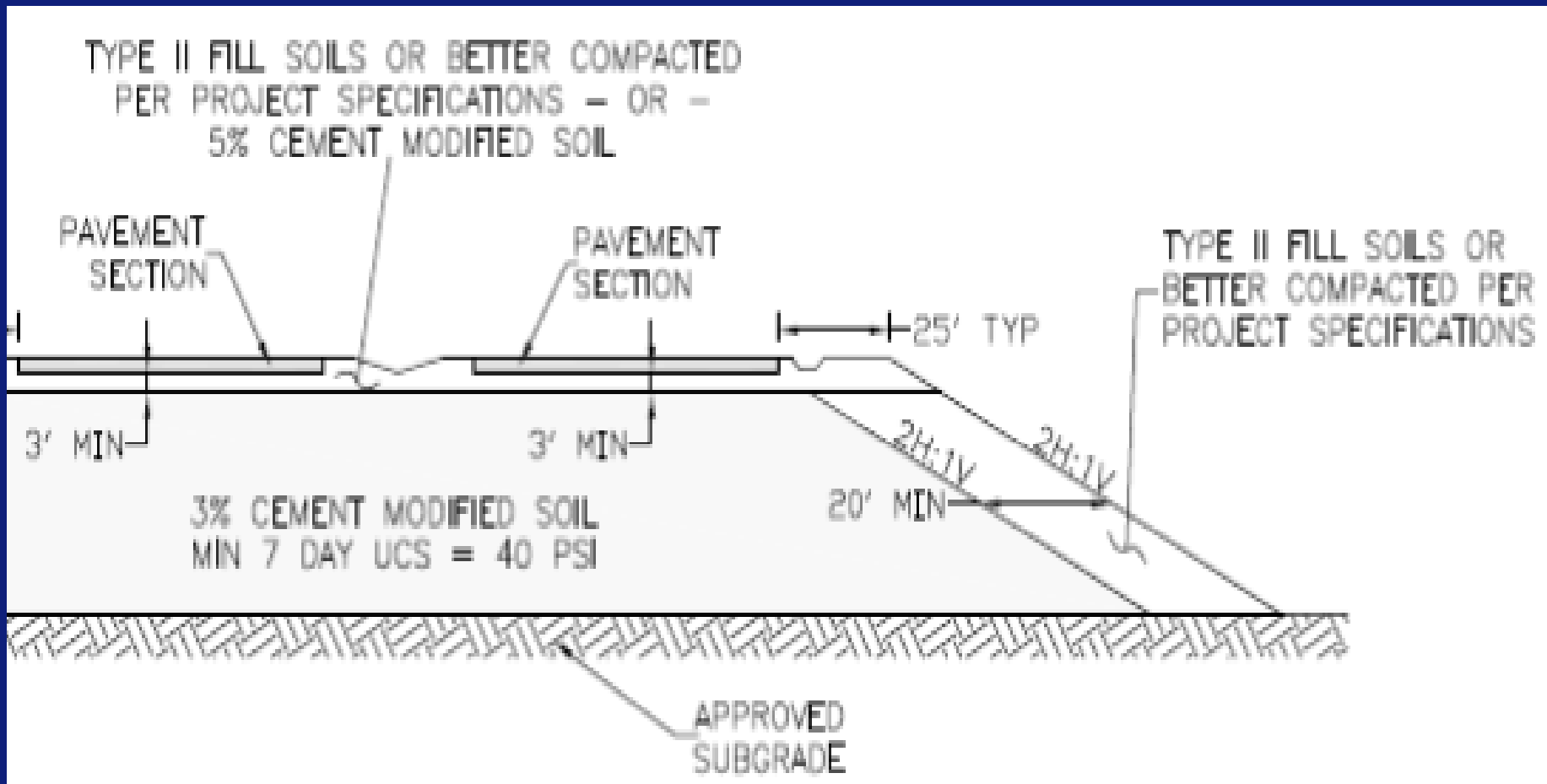
Solution



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Solution

- Pavement Subgrade
  - Use specified subgrade soils
    - Durability
    - Support
- Landscaping
  - Use specified soils
- Leachate
- Slope Stability
  - Shell soils
  - Core soils
- Compressibility

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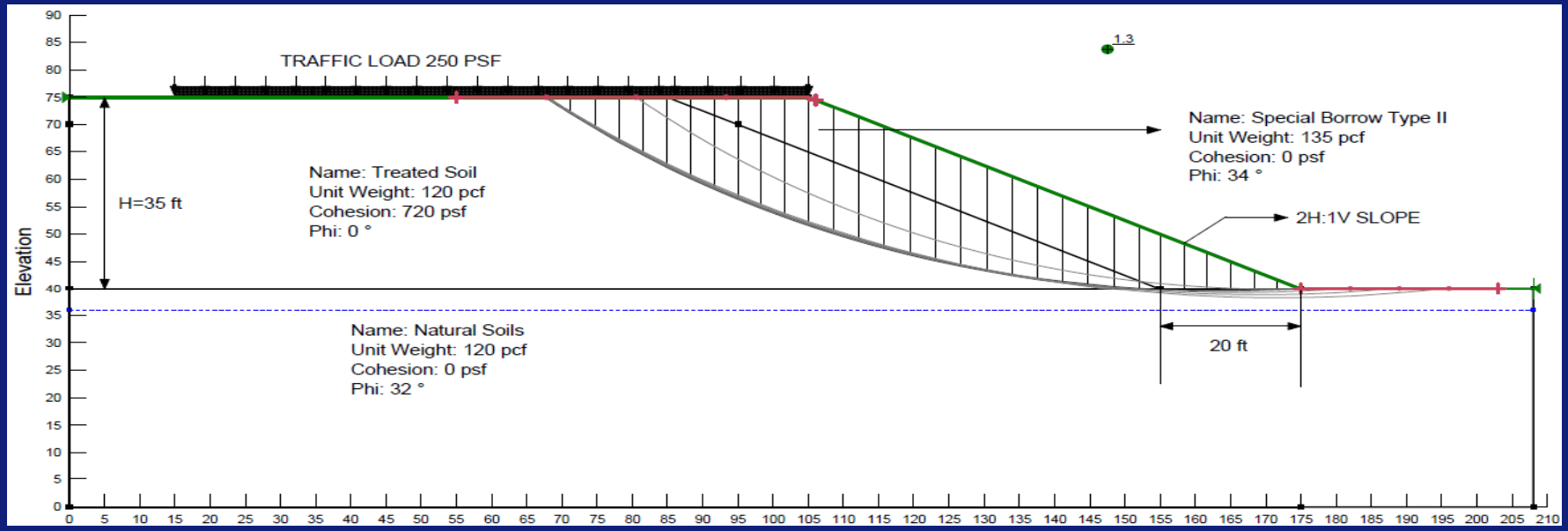
Analyses

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



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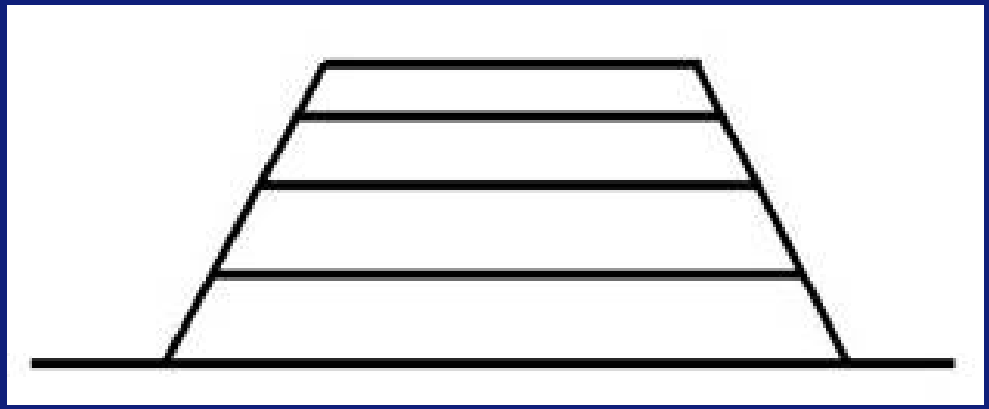
Analyses

- 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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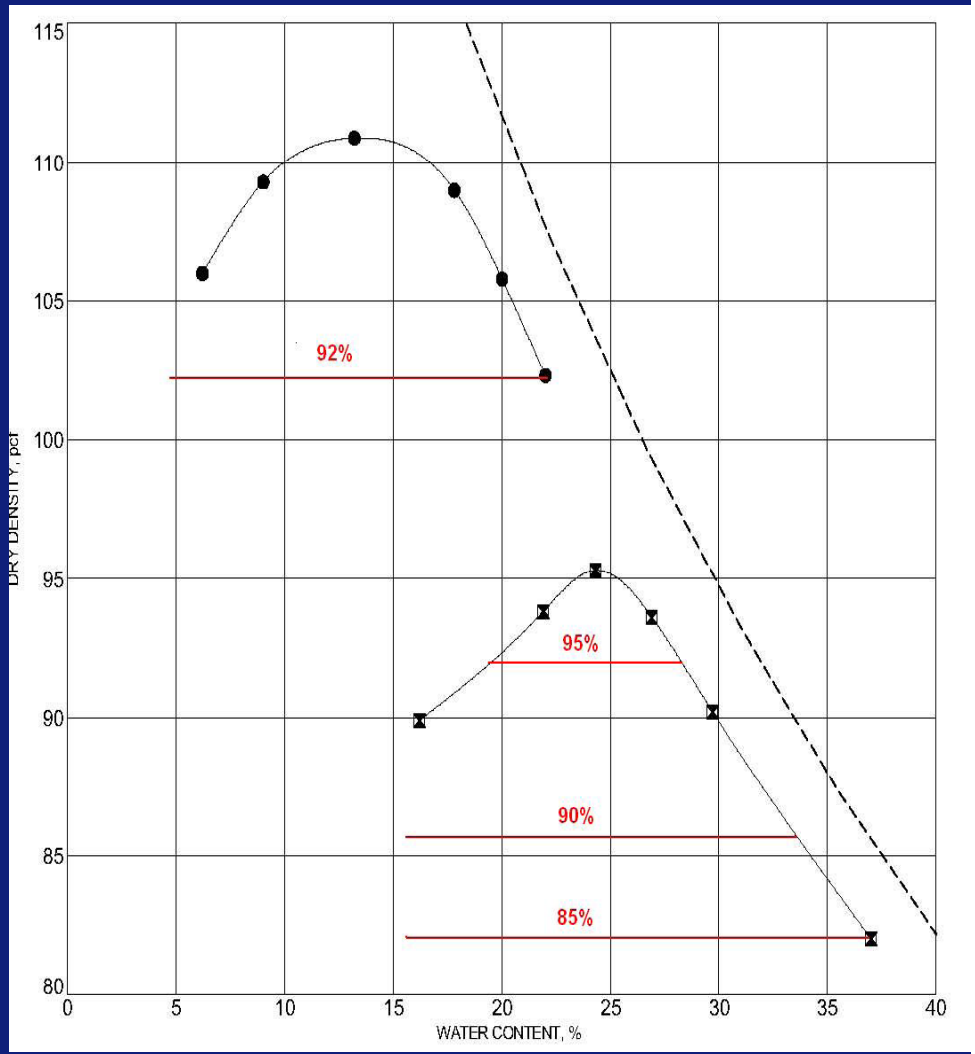
Results

- 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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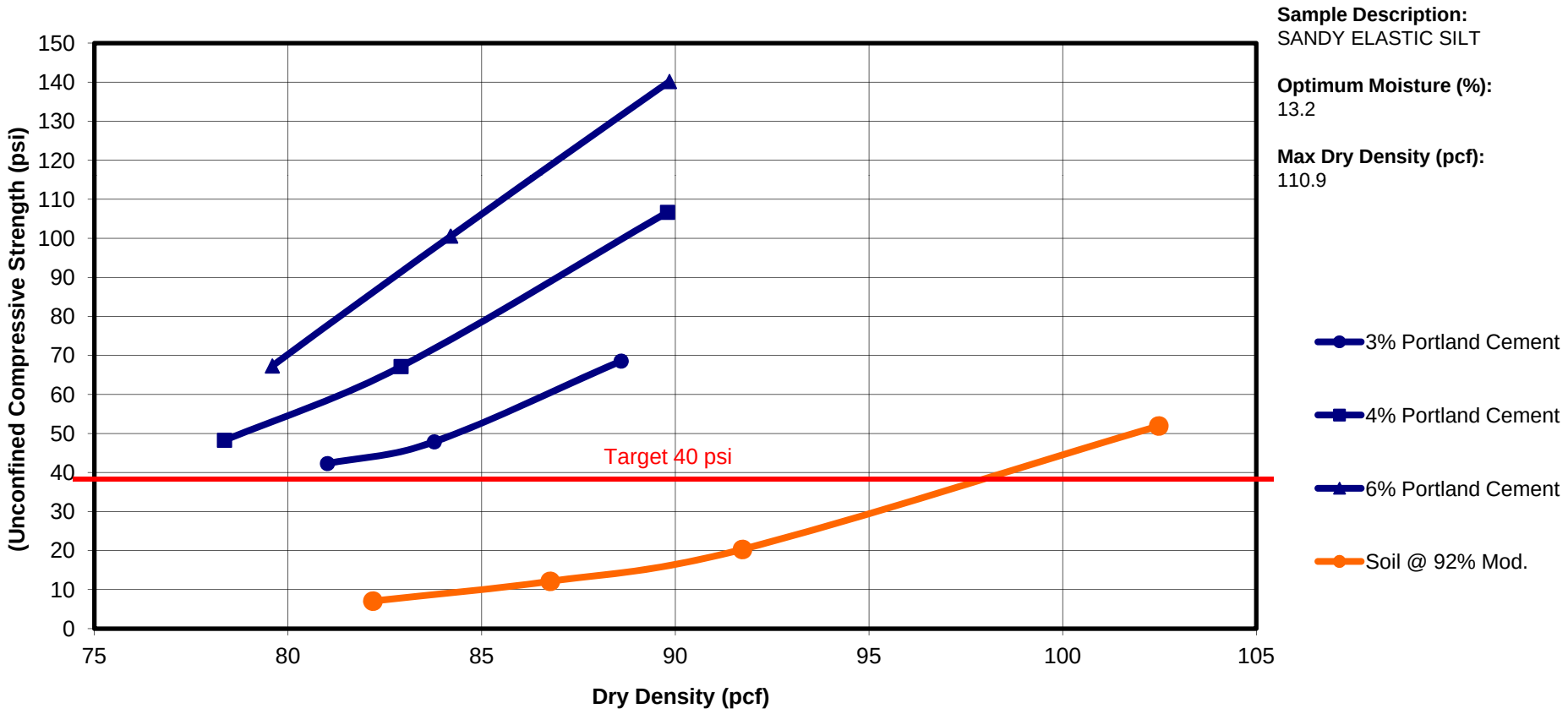
Results

Unconfined Compressive Strength vs. Dry Density
7-Day Results



Sample Description:
SANDY ELASTIC SILT

Optimum Moisture (%):
13.2

Max Dry Density (pcf):
110.9

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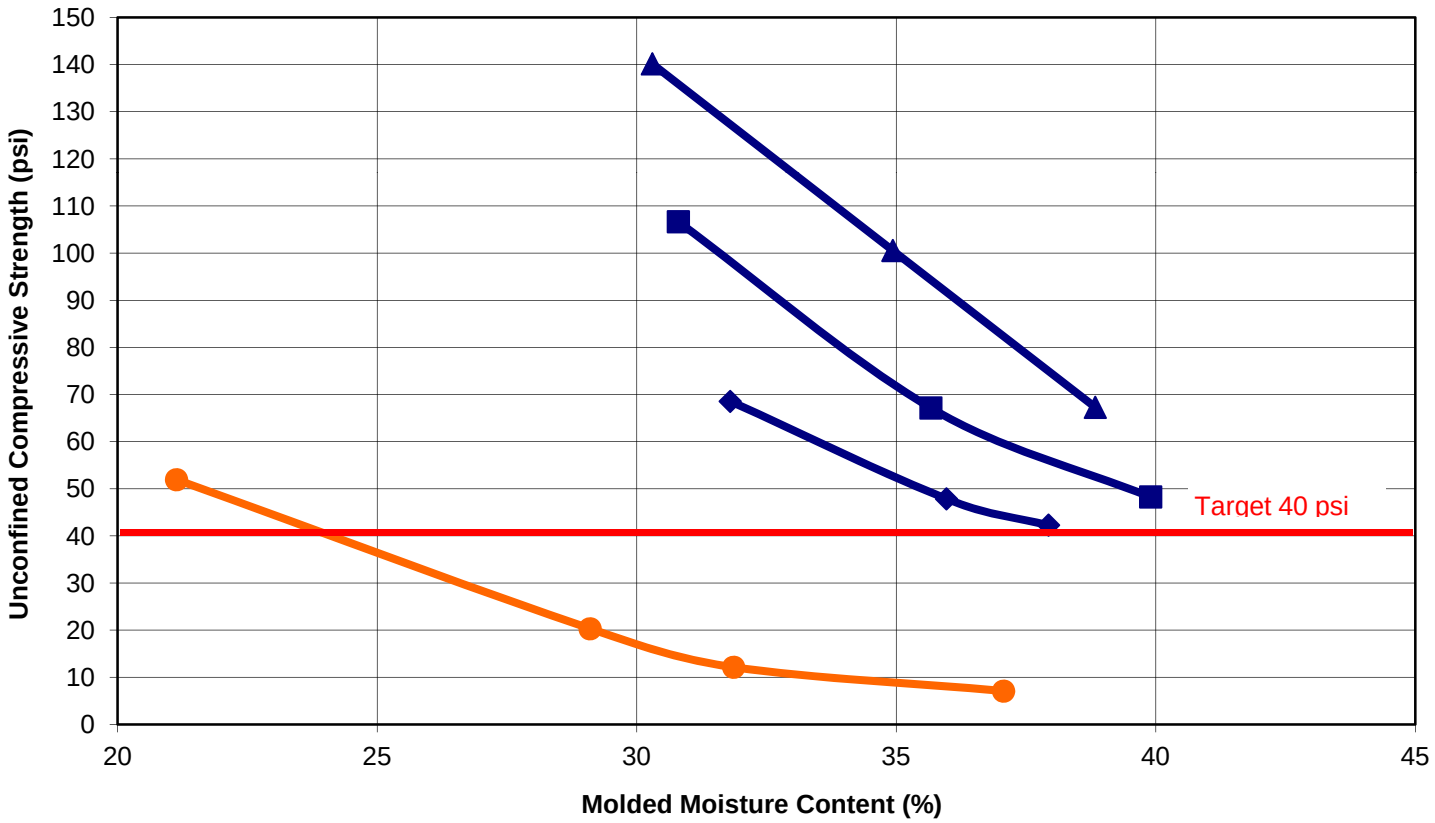
Results

Unconfined Compressive Strength vs. Moisture Content
7-Day Results



Sample Description:
SANDY ELASTIC SILT

Optimum Moisture (%):
13.2

Max Dry Density (pcf):
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3% Portland Cement
4% Portland Cement
6% Portland Cement
Soil@ 92% Mod.

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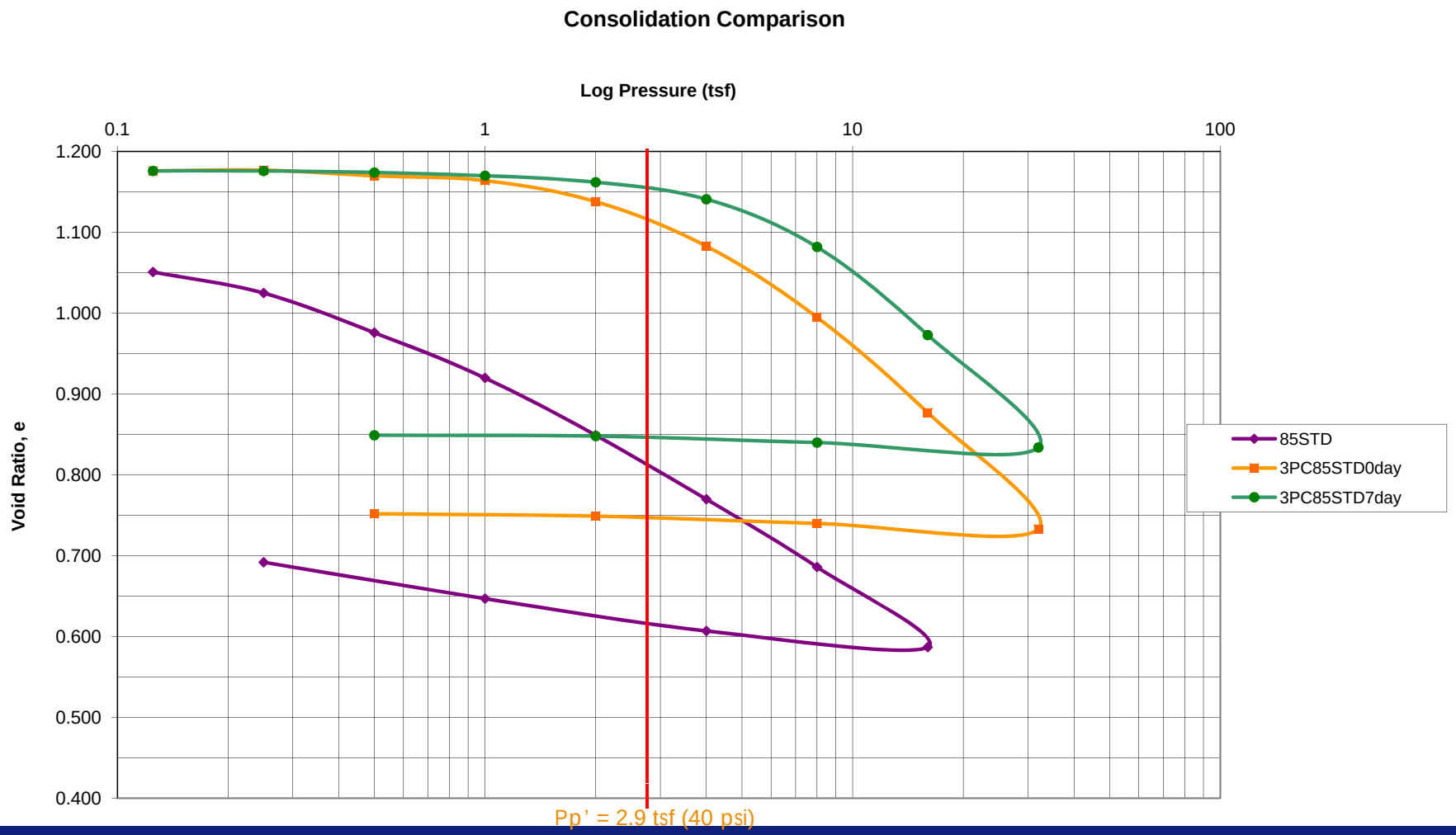
Results



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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!
  - Concept allowed Contractor to place fill
  - Met project schedule
  - ICCB – dropped zone, increased cement & compaction

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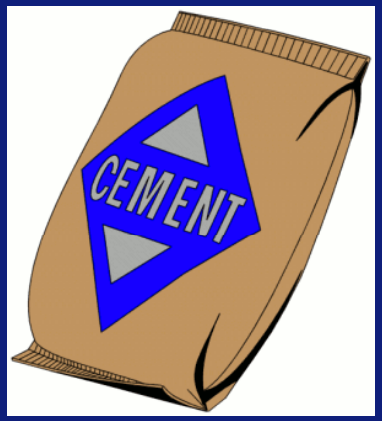
Lessons Learned

- Cement useful at low doses
- Same cement used in lab testing must be used in the field
- Considering cement modification costly and time consuming
  - Warn client of costs and time
  - Need long lead time to study



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Lessons Learned

- Need field procedures to mimic lab results
  - Expect variations
  - FS to account for variability in field/lab methods

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QUESTIONS?

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