BASE STABILIZATION IN ALASKA

2011 Asphalt Summit
Anchorage
November 1, 2011

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Information Provided by Dr. Gary Hicks. Information was disseminated to DOT&PF in a series of workshops in 2002.

Web link: Alaska Soil Stabilization Design Guide

http://www.dot.state.ak.us/stwddes/research/assets/pdf/fhwa_ak_rd_01_06b.pdf
Topics
- Background information
- Why Base Stabilization?
- Material Selection & Suitability
- Design Process
- What has been used in Alaska
- Equipment and Materials Availability
- Construction Issues in Alaska
- Weather
- Expected Properties

Why Base Stabilization?
- Improves Road Foundation to Carry Load
- Can Reduce Frost Susceptibility
- Can be a Temporary Wearing Surface
- Improves Marginal Materials (base and/or subgrade)
- Dust control
- Policy: AKFPD Policy and Procedure
- (GP -5, GP 6, GP 7 & Section 2.3)
- “To the extent possible, eliminate load restrictions”

Conditions Vary Dramatically
Types of Stabilization

- Cementing (strength gain)
  - lime
  - lime/fly ash
  - portland cement
  - asphalt
- Modifiers
  - Lime
  - Chemicals
- Waterproofers
  - bitumens
  - chemicals
- Water-retainers
  - Salts
  - Others?

Most Widely Used Stabilization Admixtures in Alaska

- Asphalt emulsions
- Foamed Asphalt (uses paving grade asphalt)
- Portland Cement
- Salts
- Enzymes (ParZyme and others)

Description of Stabilizer Effects

- Cementing agents (Lime, Cement, Asphalt)
  - Bonds individual soil particles
  - Portland cement & lime react with clay minerals (pozzolanic reaction)
  - Lime/Fly Ash effective when the clay mineral contents are low or non-existent.
  - Portland Cement - Hydrates and produces a strong cementing agent. Increases strength. Can result in reduced pavement thickness.
Description of Stabilizer Effect (cont.)
- **Modifiers** (lime, chemicals)
  - Change properties of water (absorbed layer)
  - Reduces plasticity (raise optimum water content)
  - Improves workability
  - Modifies clay minerals

Description of Stabilizer Effect (cont.)
- **Waterproofers** (Asphalt and Chemicals)
  - Reduces or stops water absorption
  - Prevents water from reaching water sensitive soils
- **Water retainers** (Salts: Calcium, Magnesium Sodium chloride or others)
  - Reduces vapor pressure - soil stays moist
  - Lowers freezing point - mitigates frost damage

Factors to Consider in Selection of Stabilization Admixture
- Gradation
- Plasticity Index
- **WEATHER!**********
- Availability of admixture
- Availability of equipment
- Economics (equipment and materials)
Soil Types Most Effective Stabilizers

2. Fine granular soils: Portland cement, lime-fly ash, asphalt, chlorides
3. Clays of low plasticity: Portland cement, chemical waterproofers, lime, lime-fly ash
4. Clays of high plasticity: Lime

Guide to Choice of Admixtures

Climatic Limitations / Construction Safety Procedures: Asphalt Products

<table>
<thead>
<tr>
<th>Climatic Limits</th>
<th>Construction Safety Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature should be above 50 F (10 C) when using emulsions.</td>
<td>Some cutbacks have flash and fire points below 100 F (40 C)</td>
</tr>
<tr>
<td>Air temperature should be 40 F (5 C) and rising when placing thin lifts (1-in.) of hot mixed asphalt concrete.</td>
<td>Hot mixed asphalt concrete temperatures may be as high as 350 F (175 C)</td>
</tr>
<tr>
<td>Hot, dry weather is preferred for all types of asphalt stabilization.</td>
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</tr>
</tbody>
</table>
### Climatic Limitations and Construction Safety Procedures

#### Cement and Fly Ash

<table>
<thead>
<tr>
<th>Climatic Limitations</th>
<th>Construction Safety Precautions</th>
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<tbody>
<tr>
<td>- Do not use with frozen soils</td>
<td>- Cement should not come in contact with moist skin for prolonged periods of time</td>
</tr>
<tr>
<td>- Air temperature should be 40°F (5°C) and rising</td>
<td>- Safety glasses and proper protective clothing should be worn at all times</td>
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<tr>
<td>- Complete stabilized layer one week before first hard freeze</td>
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</table>

#### Lime and Fly Ash

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<tr>
<td>- Do not use with frozen soils</td>
<td>- Quicklime should not come in contact with moist skin</td>
</tr>
<tr>
<td>- Air temperature should be 40°F (5°C) and rising</td>
<td>- Hydrated lime [Ca(OH)₂] should not come in contact with moist skin for prolonged periods of time</td>
</tr>
<tr>
<td>- Two weeks of warm to hot weather are desirable prior to fall and winter temperatures</td>
<td>- Safety glasses and proper protective clothing should be worn at all times</td>
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#### Salts

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<th>Climatic Limitations</th>
<th>Construction Safety Precautions</th>
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<td>- Do not use with frozen soils</td>
<td>- Require MSDS</td>
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<td>- Salts ??</td>
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### Climatic Limitations/Construction Safety Procedures: Chemicals

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<th>Construction Safety Precautions</th>
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<tr>
<td>- Do not use with frozen soils</td>
<td>- Require MSDS for each chemical</td>
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<tr>
<td>- Chemicals are more active at high temperatures</td>
<td></td>
</tr>
</tbody>
</table>

### ASPHALT STABILIZATION
**PRIMARY METHOD USED IN ALASKA**

### Stabilization with Asphalt
- Compatible with most soils in Alaska
- Soil - asphalt reactions/asphalt breaking and curing
- Properties of treated soils
- Mix design
- Construction
- Examples
**Reasons for Use**
- Waterproofing fine-grained soils.
- Reduces or eliminates frost susceptibility after treatment.
- Improves marginal materials.
- Provides temporary/permanent wearing surfaces.
- Reduces dust.

**Types of Asphalts**
- Emulsions (Anionic and Cationic)
  - Slow setting (SS)
  - Medium setting (MS)
- Cutbacks (generally not available)
  - Slow cure (SC)
  - Medium cure (MC)
  - Rapid cure (RC)
- May be used with lime/cement (1 to 2 %) to expedite breaking or release of diluting agents (water, or solvent).

**Emulsified Asphalt**
- Asphalt cement that has been mechanically diluted with the addition of emulsifying agents and water.
- Asphalt emulsions are comprised of ~33% water & emulsifying agent, and 67% asphalt residue.
- Asphalt residue does all the load carrying work.
- All soil particles are well coated.
- Depth of treatment typically < 8 inches (in place).
**Foamed Asphalt**
- Hot paving grade asphalt that is exposed to a small quantity of water (typically 2-2.5%), which causes the hot asphalt to expand or foam.
- The expanded asphalt readily coats soil particles it comes in contact with.
- Typically, foamed asphalt preferentially coats the fines portion of the resulting stabilized mixture, leaving the coarse particles nearly uncoated.
- Depth of treatment can be > 8 inches, with pad foot compaction equipment for deep stabilization.

**Suitable Soils**
- Non-plastic sands (PI < 10)
- Non-plastic gravels (PI < 6)
- Others?

**Soil – Asphalt Mechanisms/Asphalt Breaking and Curing**
- Mechanisms
  - Waterproofing
  - Adhesion
- Breaking and curing
  - Breaking (chemical)
  - Curing (evaporation)
Properties Considered During Mix Design of Treated Soils

- Strength and deformation characteristics
  - Compressive
  - Tensile
  - Elastic stiffness
- Durability
  - Freeze-thaw resistance
  - Stripping
- Fatigue performance
- Cost issues

Mix Design

- Procedures
  - Selection of asphalt type and grade
  - Approximate quantities
  - Detailed testing procedures
    - Modified Marshall, Hveem or other MD procedure, lab compaction at 72° F.
- Typical final asphalt contents
  - 3 to 5%
  - Depends on gradation/absorption/recycled asphalt
Typical Application Rates
- Assumes 2% Residue
- 4" treatment depth
  - 1.8 gal. emulsion, 4.5 lbs cement per yd^2
- 6" treatment depth
  - 2.5 gal. emulsion, 7 lbs of cement per yd^2

Construction Issues
- Mixing (in place or central plant)
- Placement and grading of mixture
- Compaction
- Curing
- WEATHER!!!!!!!!!!!!!
- Placement of wearing surface (HMA or surface treatment)

Performance and Cost
- Performance: Has been mostly successful
- Typical Modulus obtained: 100 to 130 KSI (fwd back-calculated)
- Cost has not varied significantly over 10 year period, typically
  $1.50 - $2.50 yd^2/inch
- Includes mixing, asphalt emulsion & cement powder

Performance- Has been mostly successful
Typical Modulus obtained: 100 to 130 KSI (fwd back-calculated)
Cost has not varied significantly over 10 year period, typically
$1.50 - $2.50 yd^2/inch
Includes mixing, asphalt emulsion & cement powder
Cold water and air are injected simultaneously into the hot asphalt.

The hot asphalt foams explosively and shoots down into the mixing chamber.
Mix Design
- Fines are critical for proper dispersion of the foamed asphalt.

Compaction & Foaming Water
- Hot Asphalt

Compaction and Grading
Day After Foam Treatment

Final Driving Surface

Reliable Web sites for more information
- TAI
- AEMA
- ARRA
- Others
CEMENT STABILIZATION

Stabilization with Portland Cement
- Suitable types of soils
- Soil-cement/cement hydration reactions
- Properties of treated soils
- Mix Design
- Construction
- Performance and Costs

Several Definitions
- **Cement Stabilized Soil**: Mixture of soil and measured amounts of portland cement and water which is thoroughly mixed, compacted to a high density and protected against moisture loss during a specific curing period.
- **Soil-Cement**: Hardened material formed by curing a mechanically compacted intimate mixture of pulverized soil, portland cement, and water. Soil-cement contains sufficient cement to pass specified durability tests.
**Several Definitions (cont.)**

- **Cement-Modified Soil**: Unhardened or semi-hardened intimate mixture of pulverized soil, portland cement, and water. Significantly smaller cement contents are used in cement-modified soil than in soil-cement.

**Suitable Soil Types**

- Good for most sands/gravels
- Also suitable for fine-grained soils with low to medium plasticity (PI < 30)

**Soil-Cement Reaction**

- Ion exchange
- Flocculation
- Pozzolanic reaction
- Carbonation
- Portland cement hydration
- Reactions can be short and long term
Properties of Cement-Treated Soils

- Compaction characteristics
- Strength and deformation characteristics
  - Tensile
  - Modulus
  - Fatigue
- Durability
  - Shrinkage
  - Freeze-thaw resistance
- Surface wear resistance

Mix Design

- Procedures
  - Approximate
  - Detailed testing
- Typical cement contents
  - 5 to 10 %
  - Too much can lead to shrinkage cracking

Typical Cement Contents

<table>
<thead>
<tr>
<th>Classifications</th>
<th>Recommended %PC* (wt)</th>
<th>Allowable Loss** (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1-a</td>
<td>GW, GP, GM, SW, SP, SM</td>
<td>3-5</td>
</tr>
<tr>
<td>A-1-b</td>
<td>GM, GP, SM, SP</td>
<td>5-8</td>
</tr>
<tr>
<td>A-2</td>
<td>GM, GC, BM, SC</td>
<td>5-9</td>
</tr>
<tr>
<td>A-3</td>
<td>SP</td>
<td>7-11</td>
</tr>
<tr>
<td>A-4</td>
<td>CL, ML</td>
<td>7-12</td>
</tr>
<tr>
<td>A-5</td>
<td>ML, MH, CH</td>
<td>8-13</td>
</tr>
<tr>
<td>A-6</td>
<td>CL, CH</td>
<td>9-16</td>
</tr>
<tr>
<td>A-7</td>
<td>OH, MH, CH</td>
<td>10-16</td>
</tr>
</tbody>
</table>

* Range to achieve satisfactory strength and durability
** Loss in weight after freeze-thaw or wet-dry test (ASTM 599 or 590)
Construction
- Mixing
- Placement
- Compaction
- Curing
- Need for surface layer (HMA or surface Treatment)

General Conclusions
- Asphalt and cement have been the most widely used stabilizers in Alaska
- In the past, the performance of the resulting stabilized base work has been mixed
- Recent work has been successful with improved equipment, specifications and information
- Stabilization materials and methods continue to be developed
- Our challenge is to use stabilization more frequently

QUESTIONS?