BASE STABILIZATION IN ALASKA

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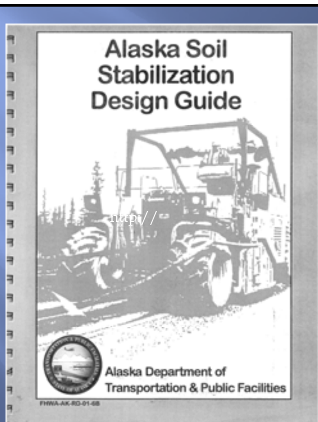
Bruce Brunette


Alaska Soil Stabilization Design Guide

Alaska Department of Transportation & Public Facilities

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

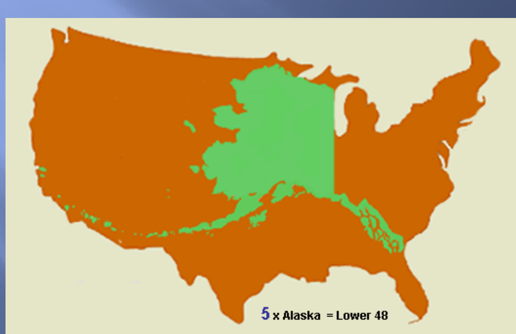
- Background information
- Why Base Stabilization?
- Material Selection & Suitability
- Design Process
- What has been used in Alaska
- Equipment and Materials Availability
- Construction Issues in Alaska
- Weather
- Expected Properties

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

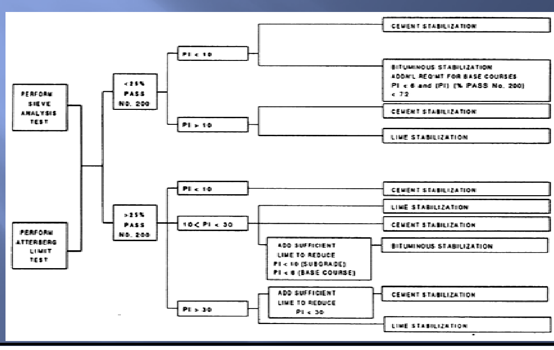
Factors to Consider in Selection of Stabilization Admixture

- Gradation
- Plasticity Index
- WEATHER!!!!!!!!!!
- Availability of admixture
- Availability of equipment
- Economics (equipment and materials)

Selection of Stabilizer Type

Soil Types	Most Effective Stabilizers
1. Coarse granular soils	Asphalt, portland cement, lime-fly ash
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

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

Climatic Limitations/ Construction Safety Procedures: Cement and Cement-Fly Ash

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

Climatic Limitations/ Construction Safety Procedures: Lime and Lime-Fly Ash

Climatic Limitations	Construction Safety Precautions
• Do not use with frozen soils • Air temperature should be 40 F (5 C) and rising • Two weeks of warm to hot weather are desirable prior to fall and winter temperatures	• Quicklime should not come in contact with moist skin • Hydrated lime [$Ca(OH)_2$] should not come in contact with moist skin for prolonged periods of time • Safety glasses and proper protective clothing should be worn at all times

Climatic Limitations/ Construction Safety Procedures: Salts

Climatic Limitations	Construction Safety Precautions
• Do not use with frozen soils • Salts ??	• Require MSDS

Climatic Limitations/ Construction Safety Procedures: Chemicals

Climatic Limitations	Construction Safety Precautions
• Do not use with frozen soils • Chemicals are more active at high temperatures	• Require MSDS for each chemical

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)

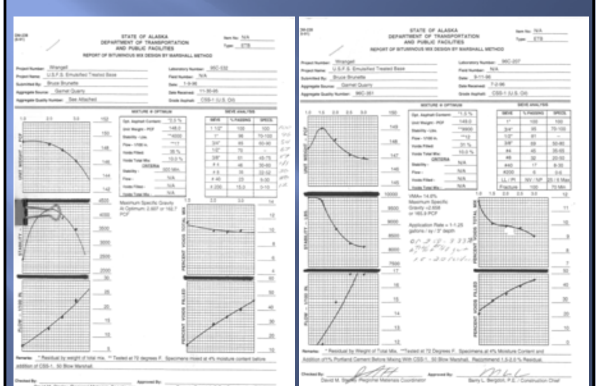
Properties Considered During Mix Design of Treated Soils

- 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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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)

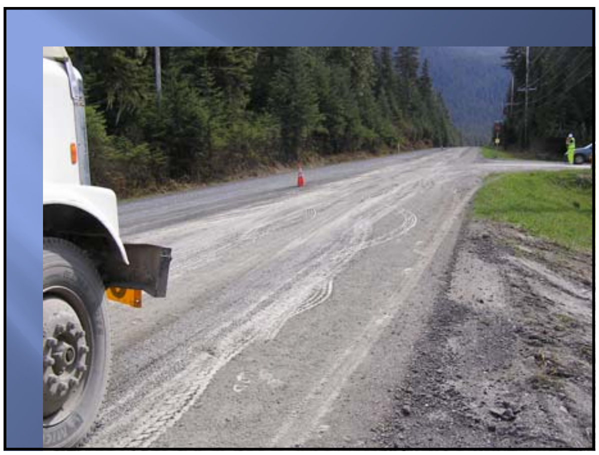
Performance and Cost

- 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

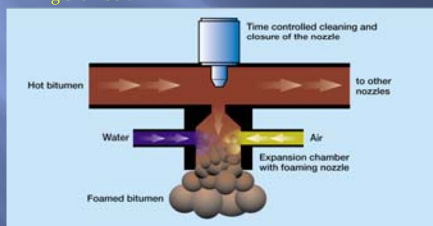

Wirtgen



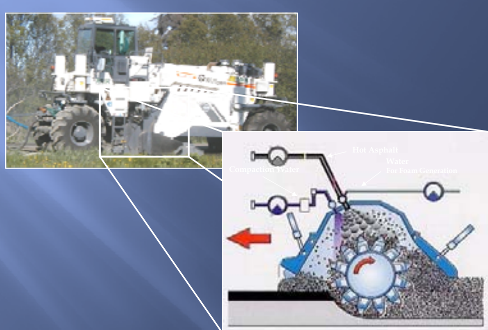

FOAMED ASPHALT
EAST & WEST HILL ROADS, HOMER
FIELD SEASON 2002

Expansion Chamber

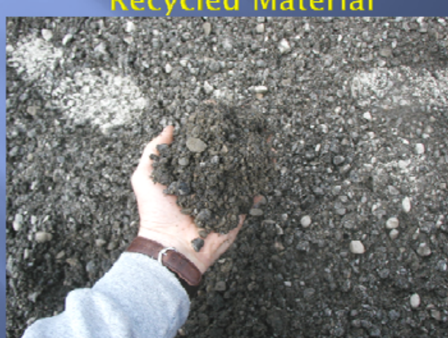
- Cold water and air are injected simultaneously into the hot asphalt.
- The hot asphalt foams explosively and shoots down into the mixing chamber.



Mixing Chamber

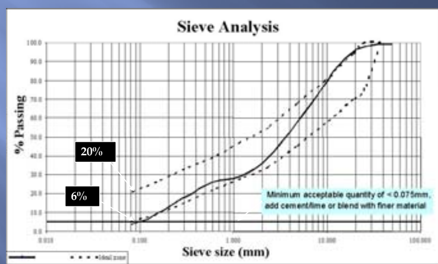


3% Asphalt Binder by Weight of Recycled Material



Mix Design

- Fines are critical for proper dispersion of the foamed 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

Classifications		Recommended %PC* (wt)	Allowable Loss** (%)
AASHTO	USCS		
A-1-a	GW, GP, GM, SW, SP, SM	3-5	14
A-1-b	GM, GP, SM, SP	5-8	14
A-2	GM, GC, SM, SC	5-9	14
A-3	SP	7-11	14
A-4	CL, ML	7-12	10
A-5	ML, MH, CH	8-13	10
A-6	CL, CH	9-15	7
A-7	OH, MH, CH	10-16	7

* Range to achieve satisfactory strength and durability
** Loss in weight after freeze-thaw or wet-dry test (ASTM 599 or 560)

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?