

Rural Roads Educational Webinar Series
UC Cooperative Extension/ Society of American Foresters

Roadway Materials, Dust Control, and Surfacing Alternatives



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ROADWAY MATERIALS

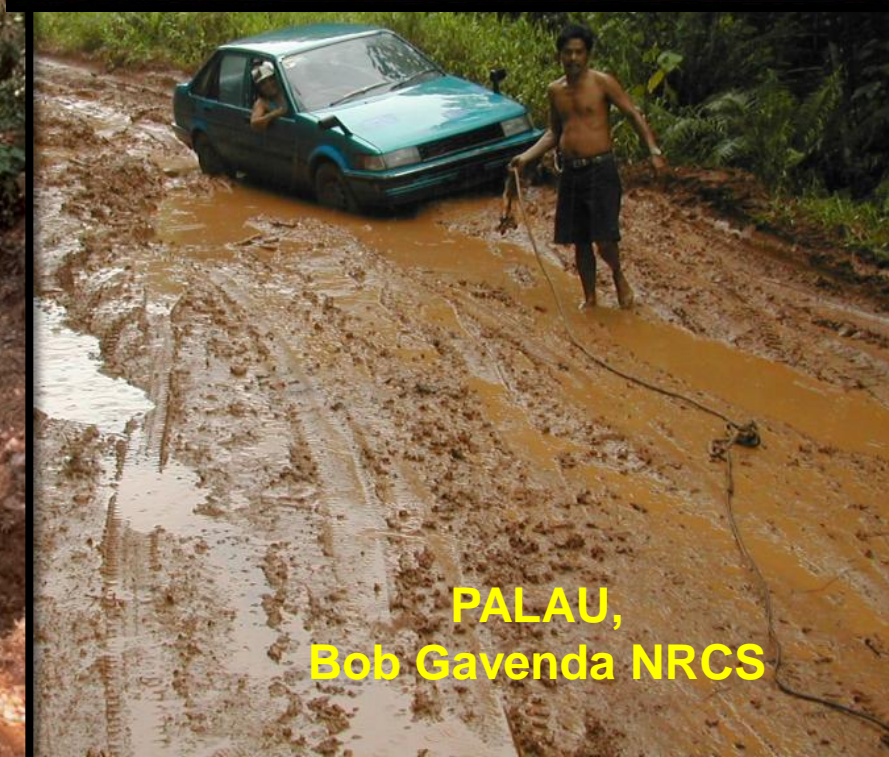
- Roadway Surfacing Alternatives
- Dust Control and Soil Stabilization
- Aggregate Design Issues
- Marginal Materials and Improvements
- Quality Control
- Materials Source Management—
Development and Reclamation

Why do we improve the road surface?

- To improve the driver comfort
- To reduce road user costs
- To get places faster
- To reduce short-term road maintenance needs
- To reduce erosion from the road surface

---But---

It costs \$\$



PALAU,
Bob Gavenda NRCS



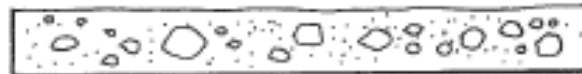
K. Skorseth, SD LTAP

Surfacing Alternatives



Figure 12.1 Commonly used low-volume road surfacing types and structural sections.

a. Native Soil



— Native (In-Place) Soil

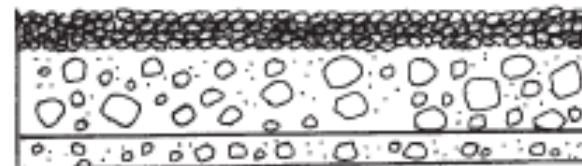
b. Aggregate



— Crushed Surface Aggregate or Gravel

— Native Soil

c. Aggregate and Base



— Crushed Surface Aggregate or Gravel

— Aggregate Base

— Native Soil

d. Cobblestone

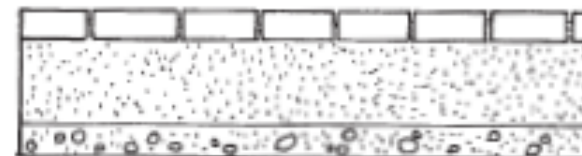


— Cobblestones

— Sand

— Native Soil

e. Concrete Block

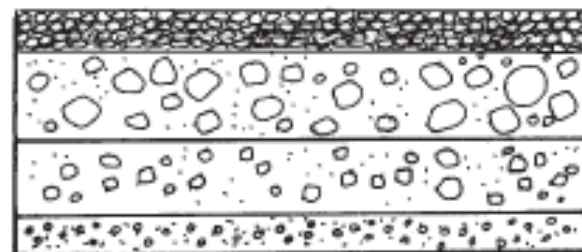


— Concrete Blocks

— Sand

— Native Soil

f. Asphalt Surfacing



— Asphalt Pavement

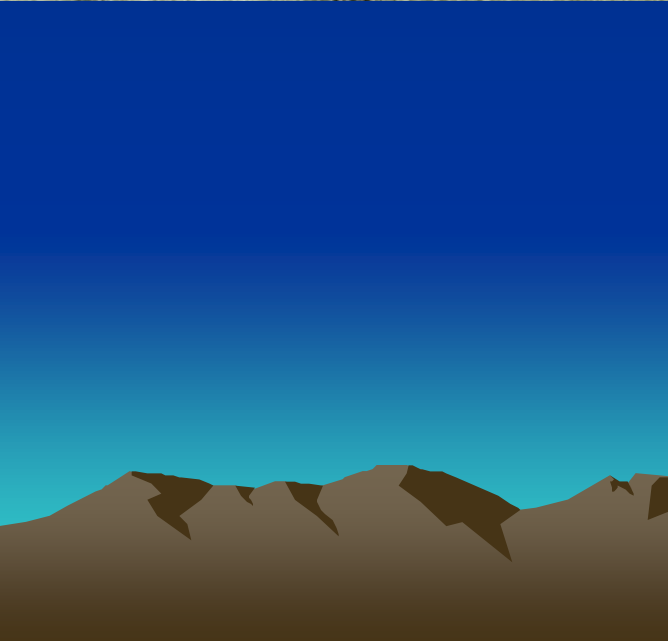
— Aggregate Base

— Aggregate Sub-Base (Optional)

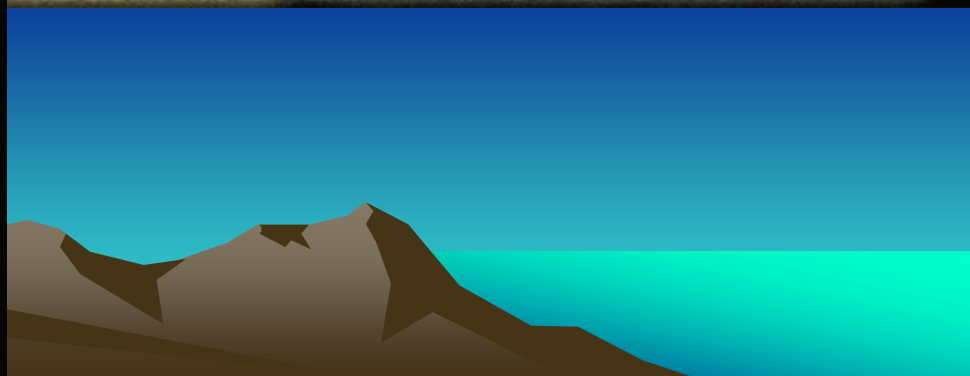
— Native Soil











Dust and Palliatives







HICKORY FLATS RD. ->
LAUREL SUMMIT RD.
INTERSECTION
AHEAD

STABILIZERS AND DUST SUPPRESSANTS


TRADITIONAL

- **Cement, Lime, Fly Ash, Asphalt, Water**
- **Moisture Absorbing Products (Hygroscopic materials):**
 - Calcium chloride
 - Magnesium chloride
 - Sodium chloride
- **Organic Petroleum Products:**
 - Asphalt emulsions
 - Liquid asphalt
 - Dust oils
 - Modified asphalt emulsion

NON-TRADITIONAL

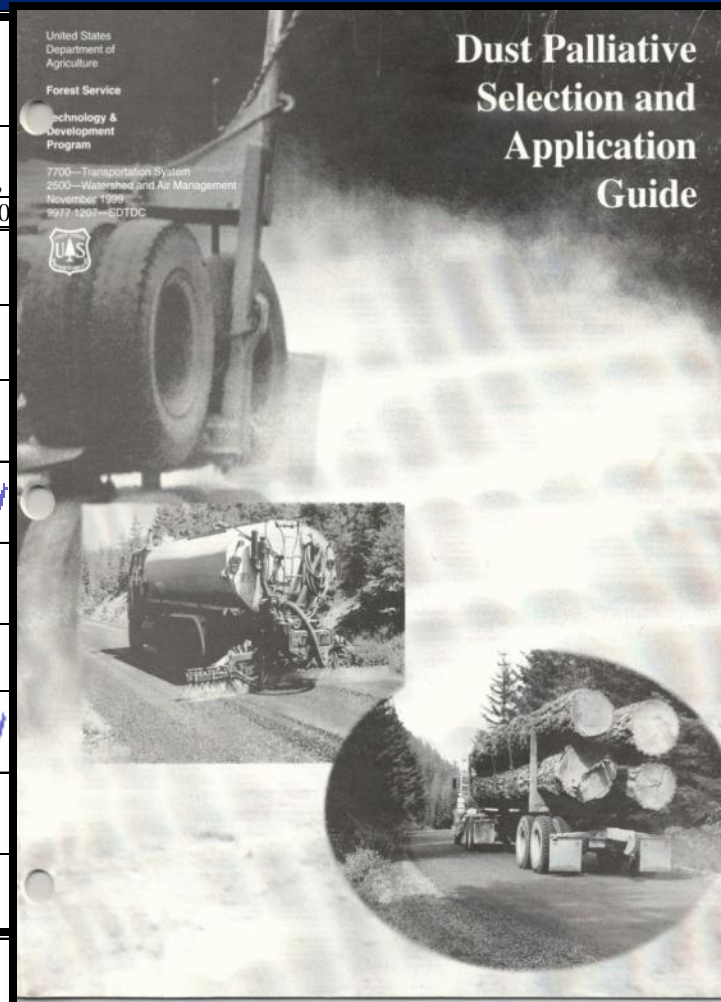
- **Organic Non-Petroleum Products:**
 - Lignosulfonates
 - Animal Fats
 - Tree Resins, Molasses
 - Tall Oils, Vegetable Oils
- **Enzymes, Synthetic Polymers, Clay Additives**

Selection Criteria

- For Traditional Stabilizers, the selection process is well documented, depending on soil type.
 - For Non-Traditional Stabilizers, application rates, methods, and effectiveness are inconsistent, not well documented, and sometimes misleading.
 - For seasonal applications, Lignins and Chlorides have the best proven performance.
 - Enzymes have good potential in clay soils, but very inconsistent performance.
 - New stabilizers need testing and evaluation.
- 

DUST PALLIATIVE PRODUCT SELECTION CHART

From: US Forest Service Publication, Bolander



Dust Palliative	Traffic Volumes, Average Daily Traffic			Surface Material						
	Light < 100	Medium 100 to 250	Heavy > 250 (1)	Plasticity Index			Fines (Passing 75µm, No. 200,			
				< 3	3-8	> 8	< 5	5-10	10-20	20-30
Calcium Chloride	✓✓	✓✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓
Magnesium Chloride	✓✓	✓✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓
Petroleum	✓	✓	✓	✓✓	✓	✗	✓ (5)	✓	✓ (6)	✗
Lignin	✓✓	✓✓	✓	✗	✓	✓✓ (6)	✗	✓	✓✓	✓✓
Tall Oil	✓✓	✓	✗	✓✓	✓	✗	✗	✓	✓✓ (6)	✓ (6)
Vegetable Oils	✓	✓	✗	✓	✓	✓	✗	✓	✓	✗
Electro-chemical	✓✓	✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓✓
Synthetic Polymers	✓✓	✓	✗	✓✓	✓	✗	✗	✓✓	✓✓ (6)	✗
Clay Additives (6)	✓✓	✓	✗	✓✓	✓✓	✓	✓✓	✓	✓	✗

Legend: ✓✓ = Good ✓ = Fair ✗ = Poor



Stabilization Selection Guide for Aggregate- and Native-Surfaced Low Volume Roads

Table C.1—Guide for selecting stabilizing additive (slight variation of table B-1) (from Army 1994)

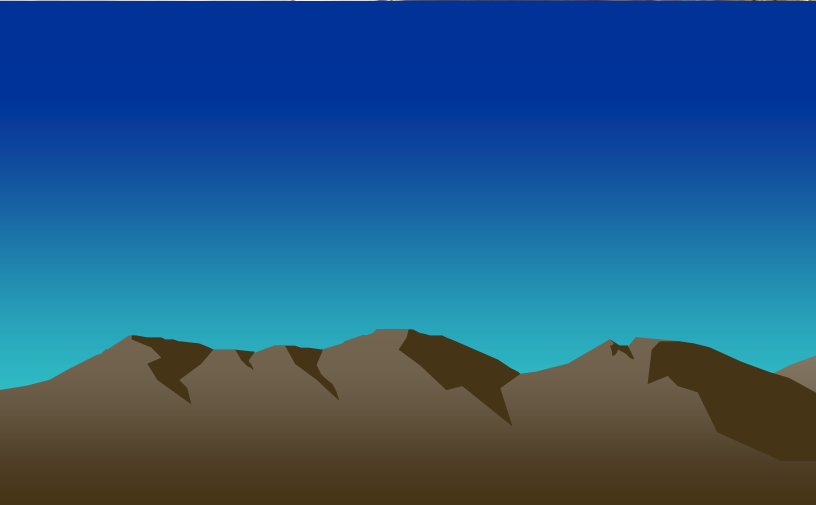
Area	Soil Class ^a	Type of Stabilizing Additive Recommended	Restriction on LL and PI of Soil	Restriction on Percent Passing No. 200 Sieve ^b	Remarks
1A	SW or SP	(1) Bituminous (2) Portland cement (3) Lime-cement-fly ash	PI not to exceed 25		
1B	SW-SM or SP-SM or SW-SC or SP-SC	(1) Bituminous (2) Portland cement (3) Lime (4) Lime-cement-fly ash	PI not to exceed 10 PI not to exceed 30 PI not to exceed 12 PI not to exceed 25		
1C	SM or SC or SM-SC	(1) Bituminous (2) Portland cement (3) Lime (4) Lime-cement-fly ash	PI not to exceed 10 .. ^b PI not less than 12 PI not to exceed 25	Not to exceed 30% by weight	
2A	GW or GP	(1) Bituminous (2) Portland cement (3) Lime-cement-fly ash	 PI not to exceed 25		Well-graded material only Material should contain at least 45% by weight of material passing No. 4 sieve
2B	GW-GM or GP-GM or GW-GC or GP-GC	(1) Bituminous (2) Portland cement (3) Lime (4) Lime-cement-fly ash	PI not to exceed 10 PI not to exceed 30 PI not less than 12 PI not to exceed 25		Well-graded material only Material should contain at least 45% by weight of material passing No. 4 sieve
2C	GM or GC or GM-GC	(1) Bituminous (2) Portland cement (3) Lime (4) Lime-cement-fly ash	PI not to exceed 10 .. ^b PI not less than 12 PI not to exceed 25	Not to exceed 30% by weight	Well-graded material only Material should contain at least 45% by weight of material passing No. 4 sieve
3	CH or CL or MH or ML or OH or OL or ML-CL	(1) Portland (2) Lime	LL less than 40 and PI less than 20 PI not less than 12		Organic and strongly acid soils falling within this area are not susceptible to stabilization by ordinary means

^a Soil classification corresponds to MIL-STD-619B. Restriction on liquid (LL) and plasticity index (PI) is in accordance with Method 103 in MIL-STD-621A.

^b $PI \leq 20 + 50 \cdot \text{percent passing No. 200 sieve}$







Aggregate Use and Requirements



Figure 12.2 Aggregate options to prevent rutting.

POOR



a. Minimal aggregate filled into ruts when they develop.

BEST

If crushed rock or gravel is not available, use coarse soil, wood chips or soil stabilizers.



c. Full structural section placed upon a reshaped compacted subgrade.

For surfacing aggregate use crushed rock, gravel or 3 cm minus rock with fines.

10-30 cm

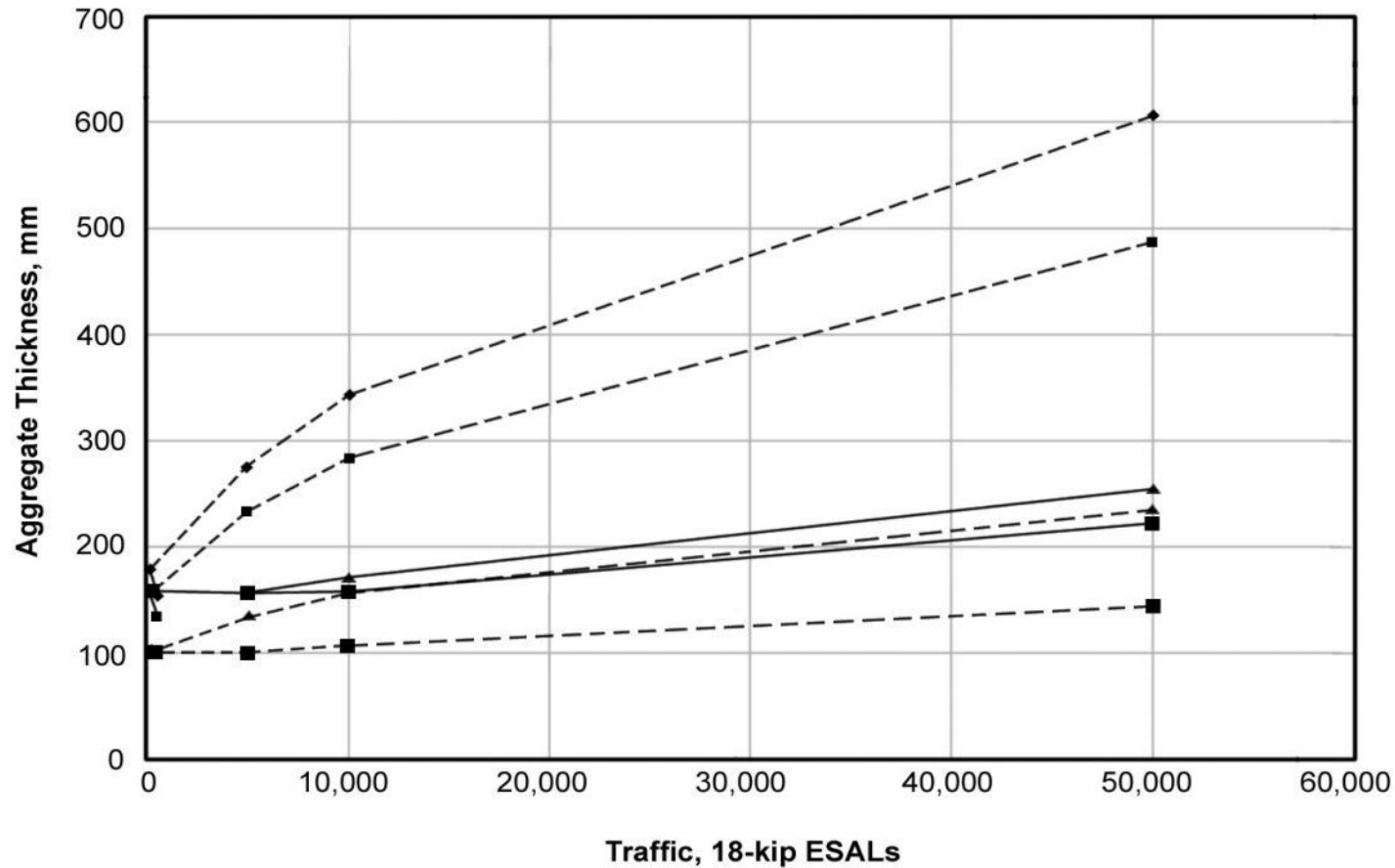
Aggregate Surface or
Asphalt Surfacing

Aggregate Base Course or Clean
Fractured Rock
(5-10 cm size or smaller)

0-30 cm min.



Surfacing Design for Aggregate



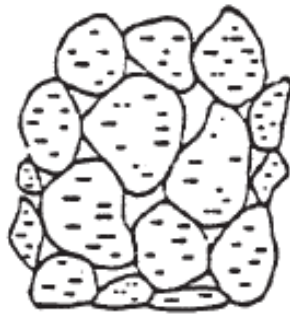
Soil Strength

- ◆— CBR 3
- CBR 5
- ▲— CBR 8
- CBR 12

Aggregate Type

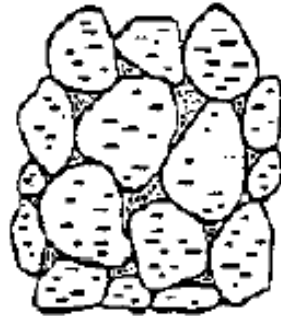
- Low Quality Aggregate
2 1/2" (70 mm) Minus
- - - - High Quality Aggregate
1" (30 mm) Minus

Figure 12.3 Physical states of soil-aggregate mixtures. (Adapted from Yoder and Witczak, 1975)



**Aggregate with
no Fines**

- Grain-to-grain contact
- Variable density
- High Permeability
- Non-Frost Susceptible
- High stability when confined, low if unconfined
- Not affected by water
- Difficult to compact
- Ravels easily



**Aggregate with
Sufficient Fines for
Maximum Density**

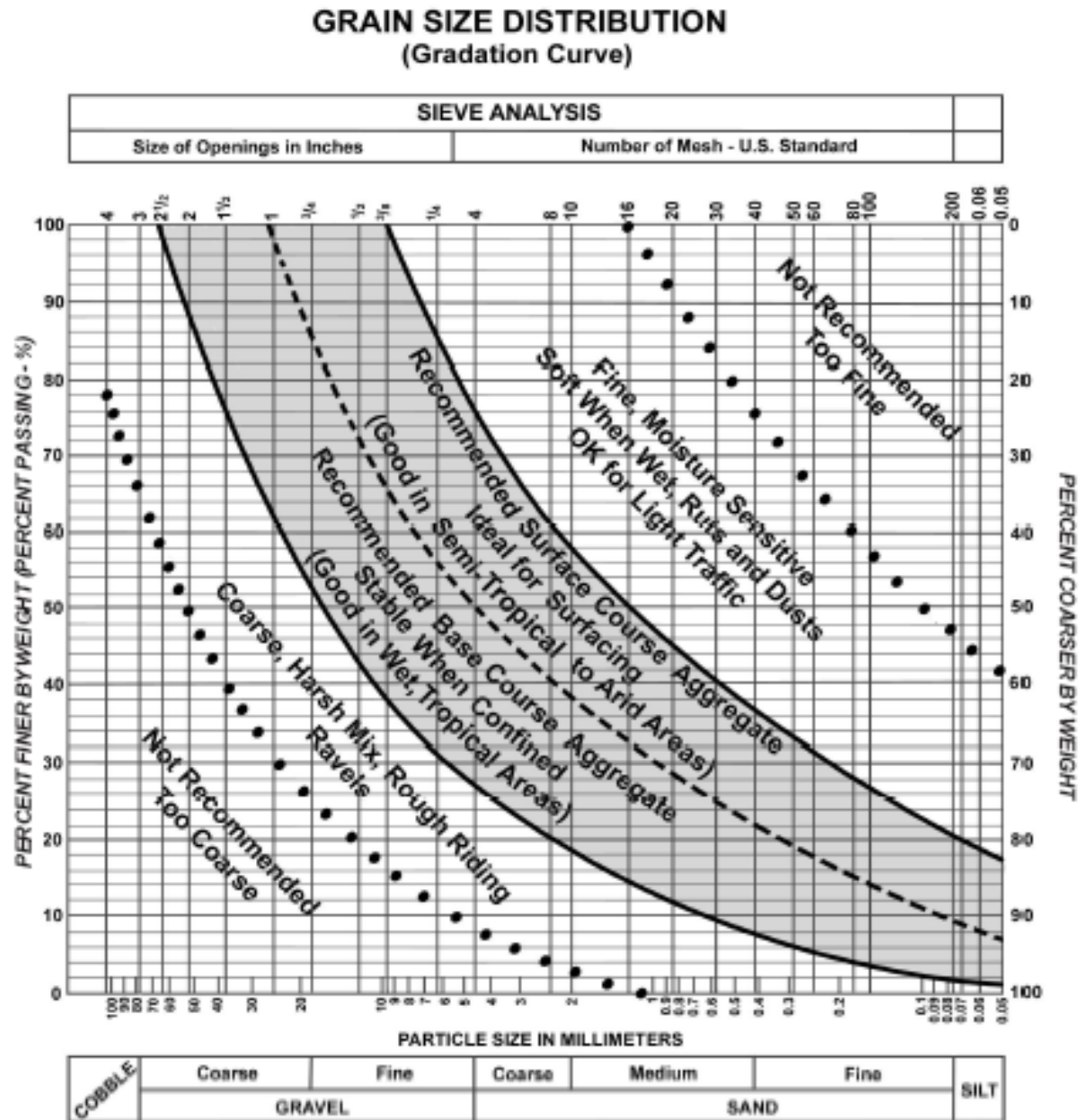
- Grain-to-grain contact with increased resistance against deformation
- Increased to maximum density
- Low permeability
- Frost susceptible
- Relatively high stability in confined or unconfined conditions
- Not greatly affected by adverse water conditions
- Moderately easy to compact
- Good road performance



**Aggregate with High
Amount of Fines
(>30 percent)**

- Grain-to-grain contact destroyed, aggregate is "floating" in soil
- Decreased density
- Low permeability
- Frost susceptible
- Low stability and low strength
- Greatly affected by water
- Easy to compact
- Dusts easily

Figure 12.4 Gradation ranges of roadway surfacing materials and their performance characteristics. (Adapted from R. Charles, 1997 and the Association of Asphalt Paving Technologists)



NOTE: Gradation Ranges Shown Are Approximate.

Requirements and Gradation for Materials used on Roads

Aggregate Base

Sieve Size	Percent Passing		
	CALTRANS Gradations Grading 1 (1 1/2")	Grading 2 (3/4")	FHWA Grading D
2"	100		
1 1/2"	90-100		100
1"		100	97-100
3/4"	50-85	90-100	
1/2"			(3/8") 56-70
#4	25-45	35-60	39-53
#8			
#30	10-25	10-30	(#40) 12-21
#200	2-9	2-9	4-8

Note: Liquid Limit (AASHTO T-89) – 25 Maximum; Plasticity Index (AASHTO T-90) – 6 Maximum; FHWA Grading D is Non- Plastic.

CALTRANS R-Value – 78 Minimum (CBR [AASHTO T-193] – 50 Minimum).

Sand Equivalent (AASHTO T-176) – 25 Minimum.

Both Surface and Base Agg: Durability (AASHTO T-210) – 35 Minimum; Percent Wear (AASHTO T-96) – 40 Maximum.

Surface Course Aggregate (USDA-Forest Service)

Sieve Size	Percent Passing		
	Grading B	Grading C	Grading D
2"	100		
1 1/2 "	60-90		100
1"		100	
3/4"		60-90	70-100
1/2"	44-70		
#4	28-50	30-55	36-60
#8	20-41	22-43	24-47
#30	9-26	11-27	12-31
#200	6-12	6-15	6-15

Note: Liquid Limit (AASHTO T-89) – 35 Maximum; Plasticity Index (AASHTO T-90) – 2-9 Maximum;



Penn State Dense Surface Aggregate (DSA)

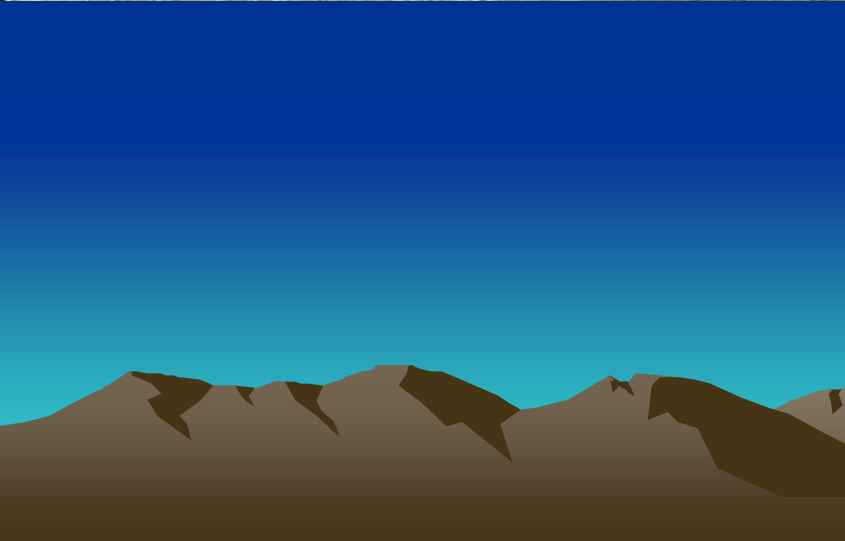
Sieve Size Analysis

Sieve Size	DSA Specification Range	Quarry's Sieve Analysis (certification)
1.5"	100%	100%
3/4"	65-95%	90%
#4	30-65%	42%
#16	15-30%	26%
#200	10-15%	12.3%

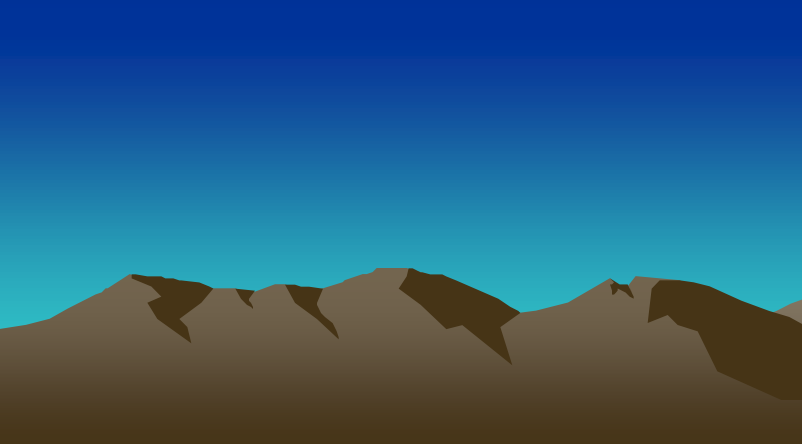
pH, L.A. Abrasion, Optimum Moisture %:

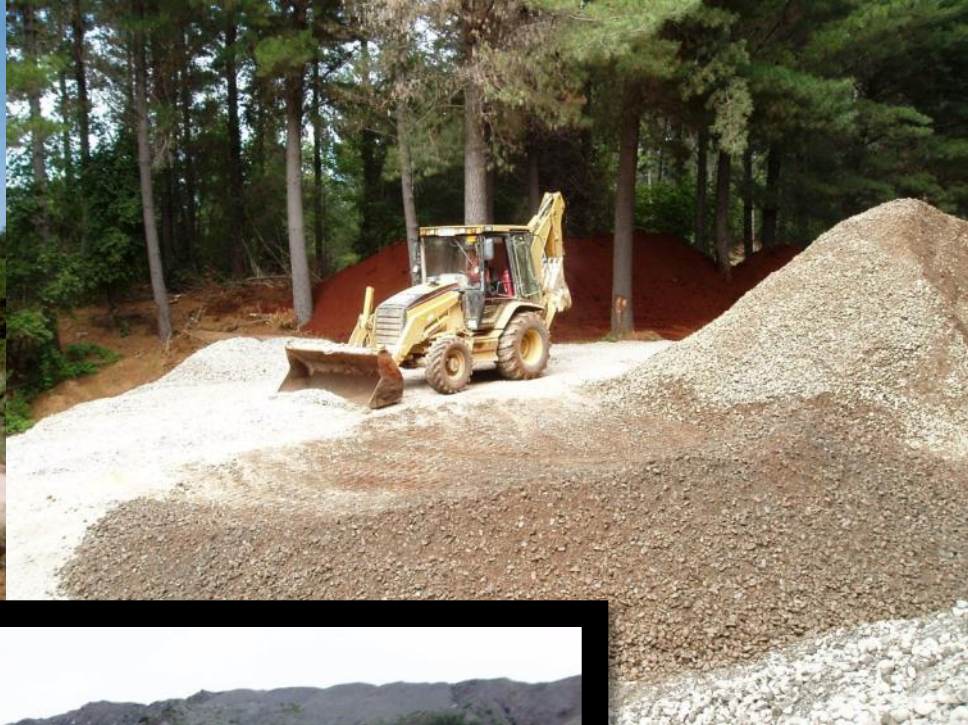


Materials Improvement









CTI





With CTI

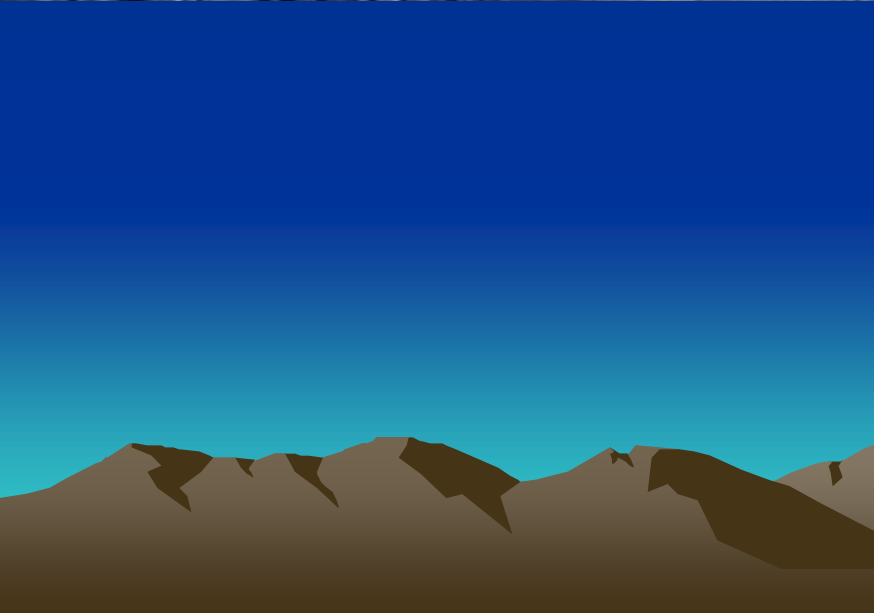
CENTRAL TIRE INFLATION



50 Truck Passes

Without CTI





Separation/Reinforcement With Geosynthetics



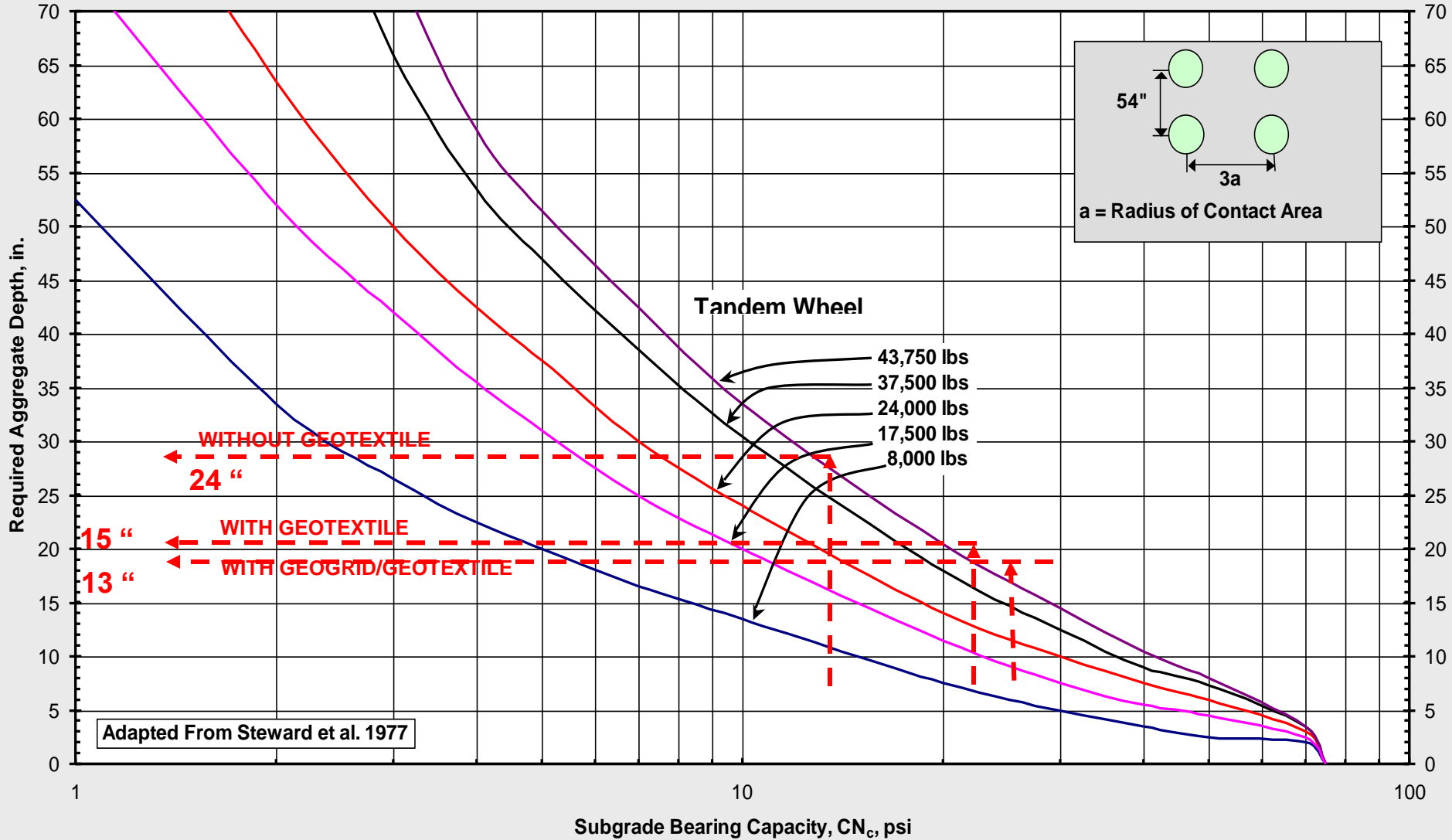


Unpaved Road Design

Tandem Wheel Gear Weight

One Layer System

Tire Pressure = 80 psi



Quality Control



CAUTION
NON-POTABLE
WATER
DO NOT DRINK



DCP- Dynamic Cone Penetrometer





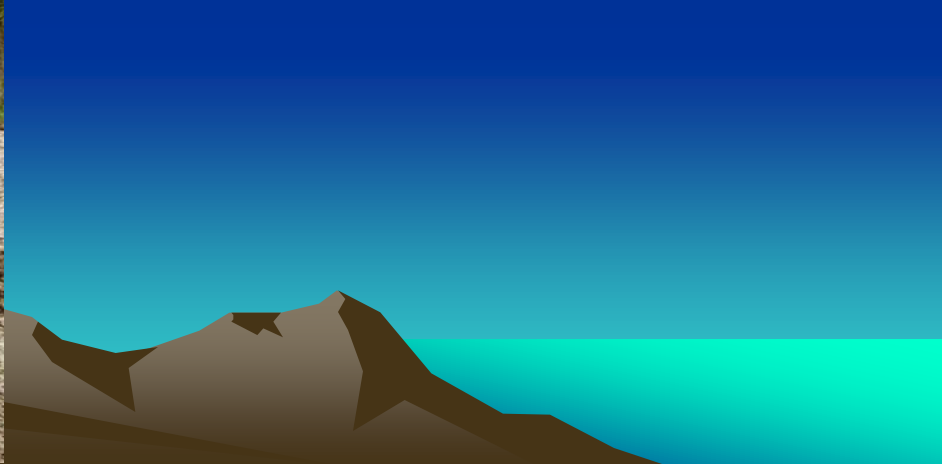
**You Get What You Inspect,
Not What You Expect**

Compaction



Compaction

- **Almost all treatments require compaction**
 - **All treatments improve w/compaction**
 - **Cheapest treatment to apply**
 - **Compaction = right size roller for the right material and properly used**
 - **Specify procedure or end result**
- 





Compaction with Water Truck

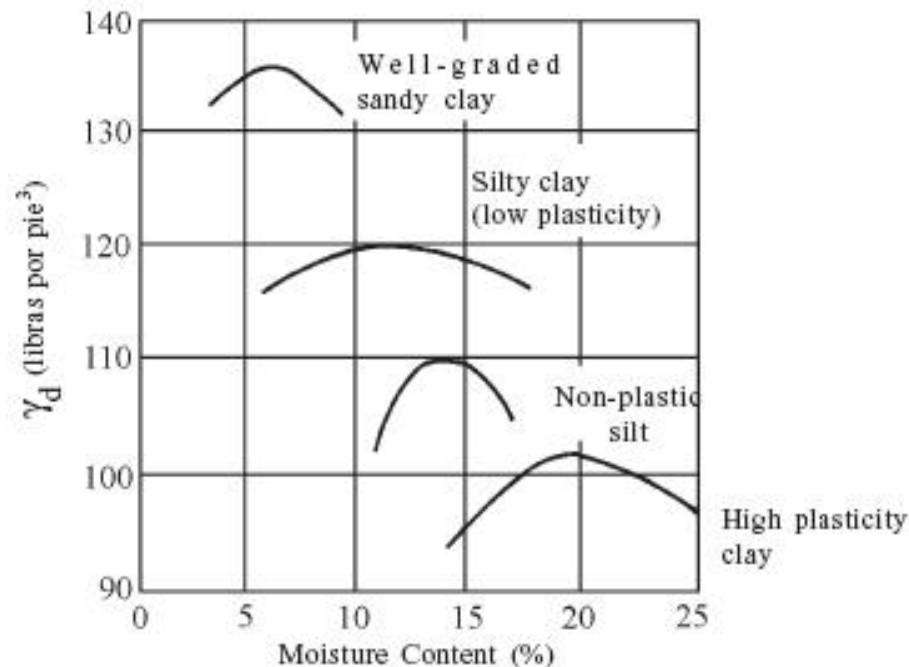


Figure B - Typical Compaction Results for Differing Soils with the Same Compactive Effort.

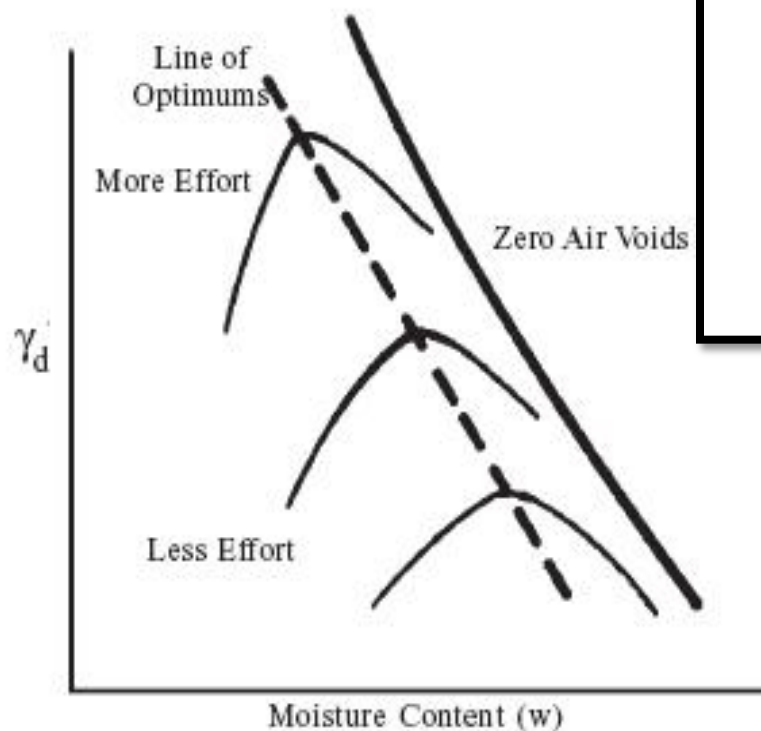


Figure A - Typical Results of Increased Compactive Effort on the Same Soil.

**REMEMBER
Drainage
IS Critical!**

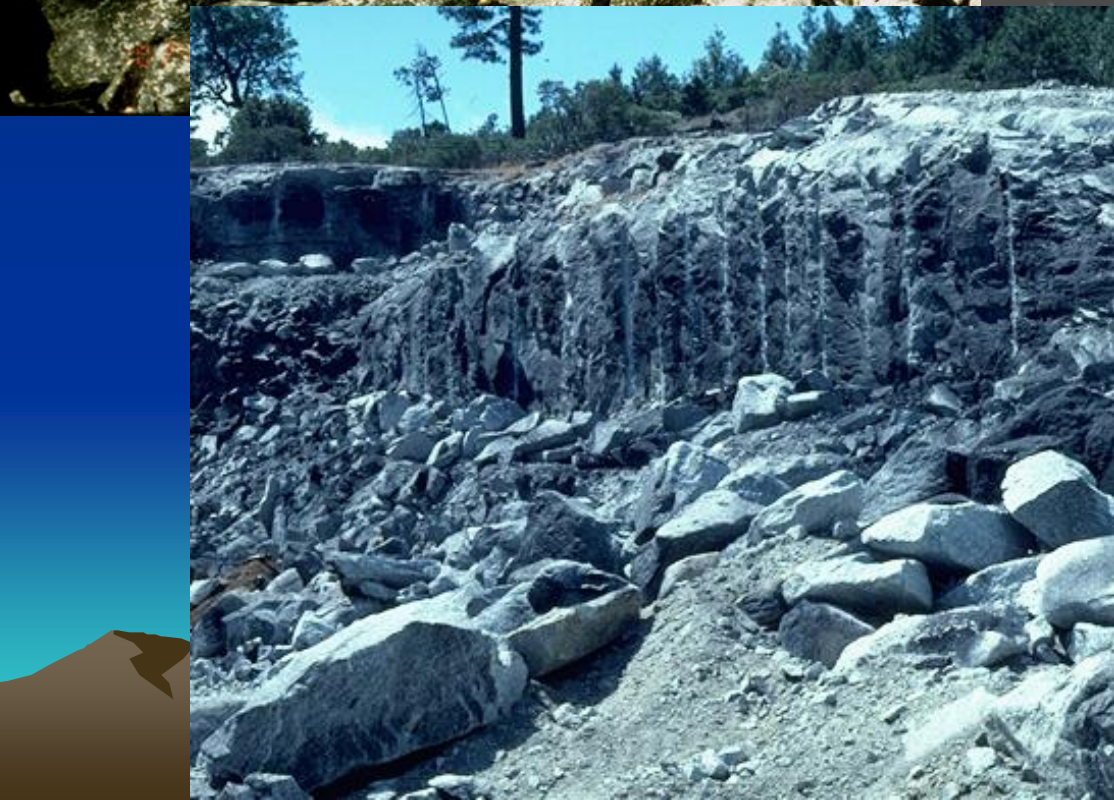


Pit or Quarry Development and Reclamation

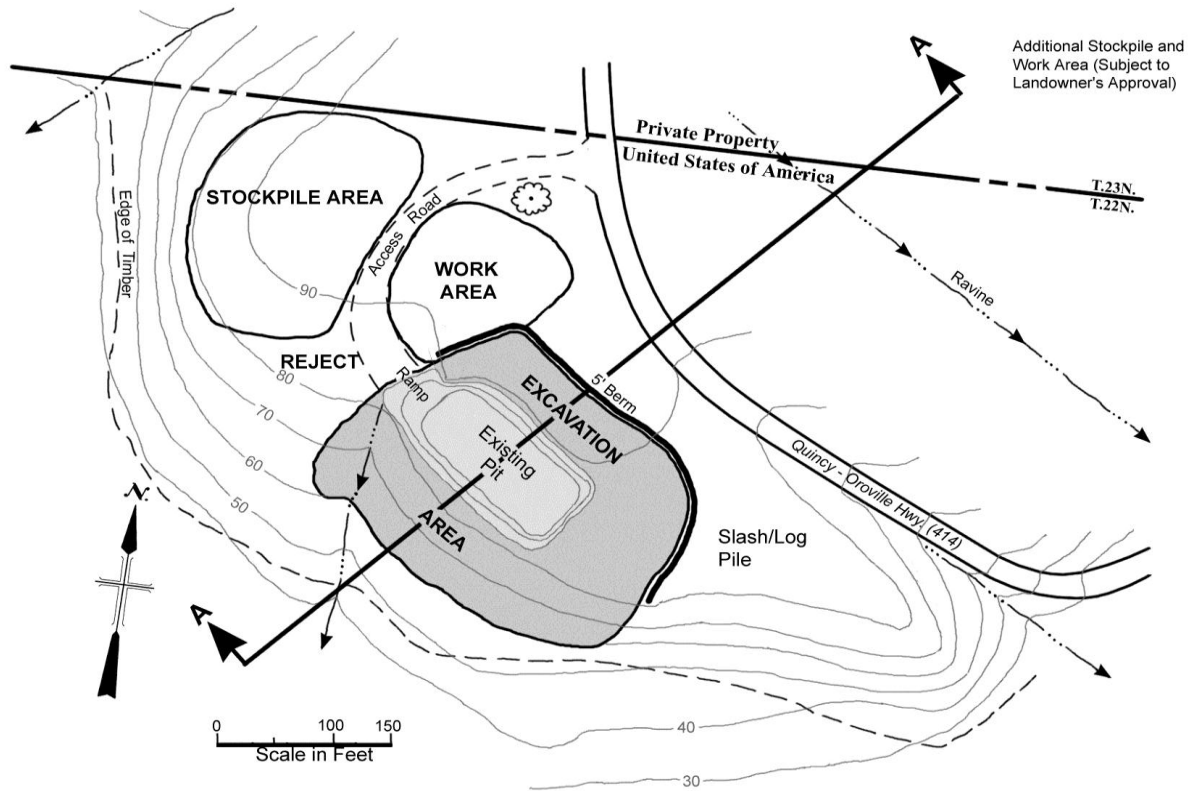


KEY QUARRY ISSUES

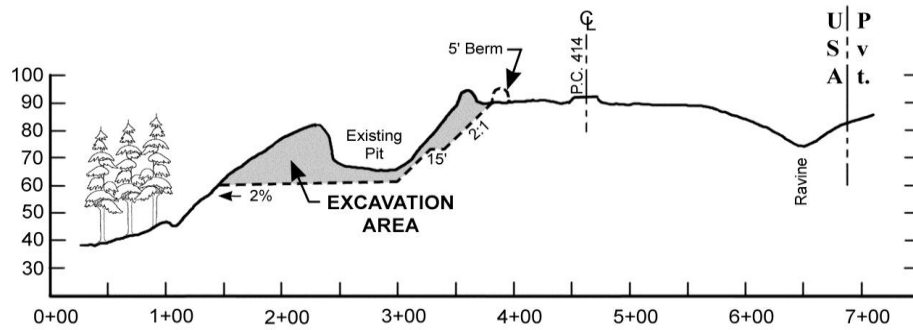
- **Locating Suitable Sources**
 - **Quantity and Quality**
- **Satisfying Environmental Requirements**
- **Site Development**
 - **Pit Development Plan**
- **Site Reclamation**







PLAN VIEW



SECTION A - A

A PIT DEVELOPMENT PLAN

Additional Stockpile and Work Area (Subject to Landowner's Approval)









Useful References

United States
Department of
Agriculture
Forest Service
Engineering Staff
Washington, DC
EM-7170-16
September 1996



Earth and Aggregate Surfacing Design Guide for Low Volume Roads

Pete Bolander, et. al



U.S. Department
of Transportation
**Federal Highway
Administration**

Gravel Roads

Maintenance and Design Manual

Ken Skorseth

South Dakota Local Transportation
Assistance Program (SD LTAP)

Report No. LTAP-02-002 November 2000



U.S. Department
of Agriculture

Forest Service

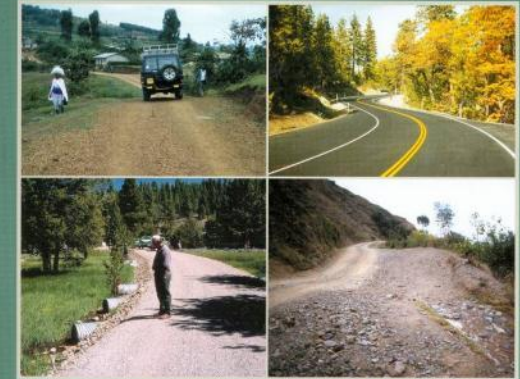
National Technology &
Development Program

7700—Transportation Mgmt
1177 1801—SD TDC
August 2011



Stabilization and Rehabilitation Measures for Low-Volume Forest Roads

LOW-VOLUME ROADS ENGINEERING



Best Management Practices
Field Guide



Gordon Keller
&
James Sherar

Environmentally Sensitive Maintenance for Dirt and Gravel Roads

- Better Roads
- Better Environment
- Better Community
- Less Maintenance



To this!



From
this.....

Alan L. Gesford, P.E.
John A. Anderson, Ph.D.

March 2006

What is Important?

- **Know your Soils and Traffic**
- **Select the Appropriate Surfacing Standard**
- **Use Appropriate Aggregate Gradation**
- **Consider In-place Soil Stabilization**
- **Use Cost-Effective Local Materials**
- **Use Adequate Q C /Sampling & Testing**
- **Compact your Soils and Aggregates**
- **Drain your Materials**
- **Develop Quarries...then Reclaim Them**





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Thank You!