MAKING BETTER GRAVEL ROADS PART 1: INTRODUCTION AND WEARING COURSE MATERIALS

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County Engineers Association of California

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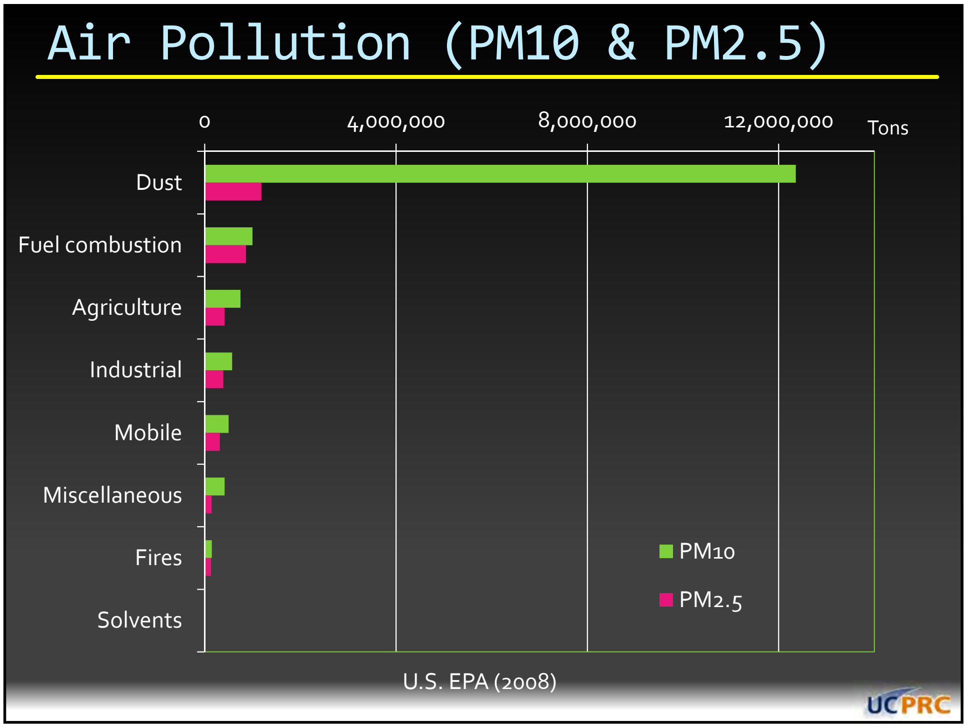
Oxford Engli
Dirt: any fou
mud, grime,
From old Nor

Outline

- Introduction
- Material specifications
- Understanding performance
- Summary

Introduction

- Unpaved roads
  - Function
  - Problems
  - Sustainability
- Range of management issues primarily funding and unpaved road expertise
- "Unpaving" projects are adding to the inventory


Air Pollution (PM10 & PM2.5)
0
4,000,000
8,000,000
12,000,000
Tons
Dust
Fuel combustion
Agriculture
Industrial
Mobile
Miscellaneous
Fires
Solvents
PM10
PM2.5
U.S. EPA (2008)
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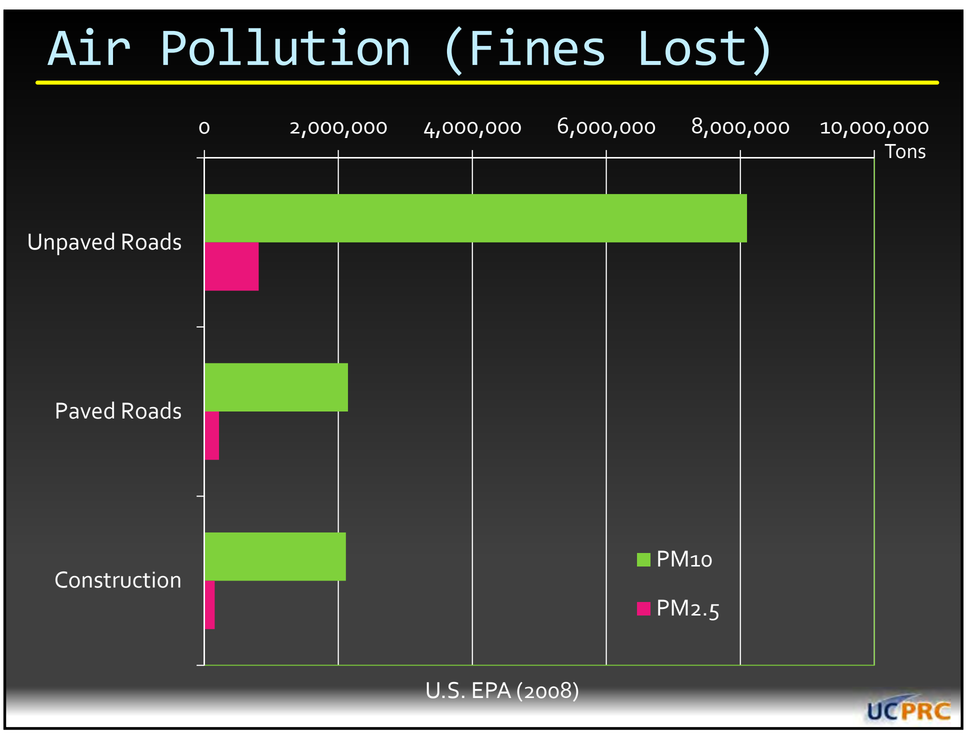
Air Pollution (Fines Lost)
0
2,000,000
4,000,000
6,000,000
8,000,000
10,000,000
Tons
Unpaved Roads
Paved Roads
Construction
PM10
PM2.5
U.S. EPA (2008)
UCPRC

Fines Lost

- In perspective
  - > 8 million tons per year
  - 267,000 30T trucks
- Fines loss from erosion (1mm/yr)
  - 14 million tons per year

Key National Issues

- No “owner” of unsealed road guides and specifications
- Often no owner of the problem
  - Oil, wind, solar, ethanol, etc.
- Limited unpaved road expertise and funding for
  - Road management
  - Research
- Fragmented products industry marketing solutions
- So what?

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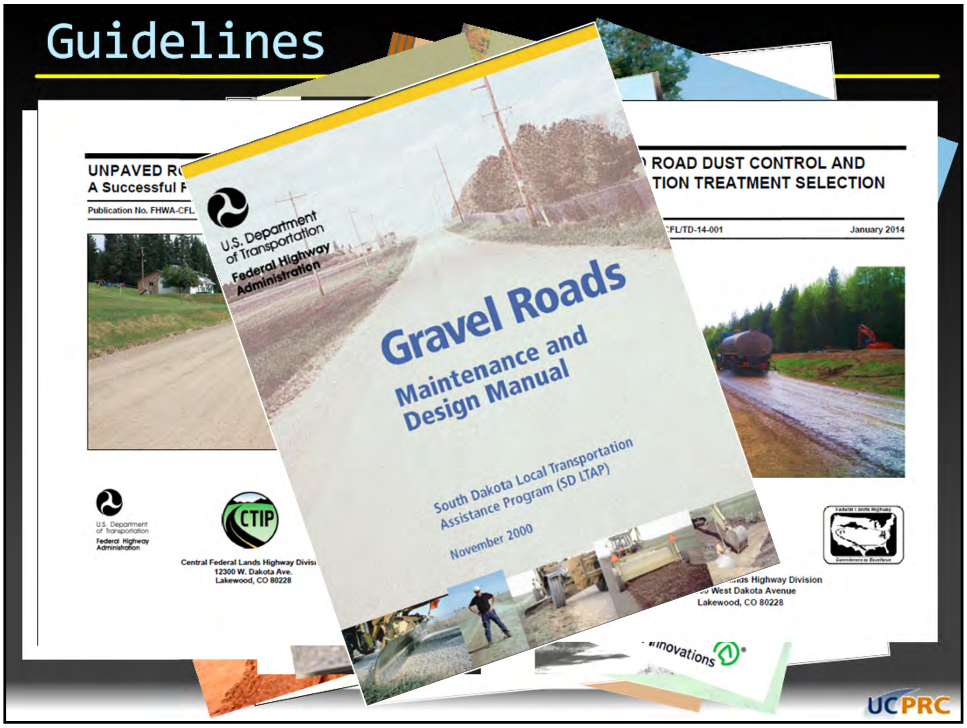
Key National Issues

- Sourcing unpaved road materials
  - Environmental constraints
  - Commercial sources dominate
  - Focus on base, asphalt, and concrete
- Material specifications
  - Everybody has one
  - Most based on AASHTO subbase requirements and adapted for local conditions
  - Most use grading envelope and PI range
  - Many specify non-plastic materials
- Construction specifications
  - Not often followed/enforced
  - Considered as an unnecessary expense
  - Life of gravel wearing course significantly reduced


Guidelines
UNPAVED R
A Successful F
Publication No. FHWA-CFL
U.S. Department of Transportation Federal Highway Administration
Gravel Roads
Maintenance and Design Manual
South Dakota Local Transportation Assistance Program (SD LTAP)
November 2000
ROAD DUST CONTROL AND
TION TREATMENT SELECTION
CFL/TD-14-001
January 2014
CTIP
Central Federal Lands Highway Divisi
12300 W. Dakota Ave.
Lakewood, CO 80228
West Dakota Avenue
Lakewood, CO 80228
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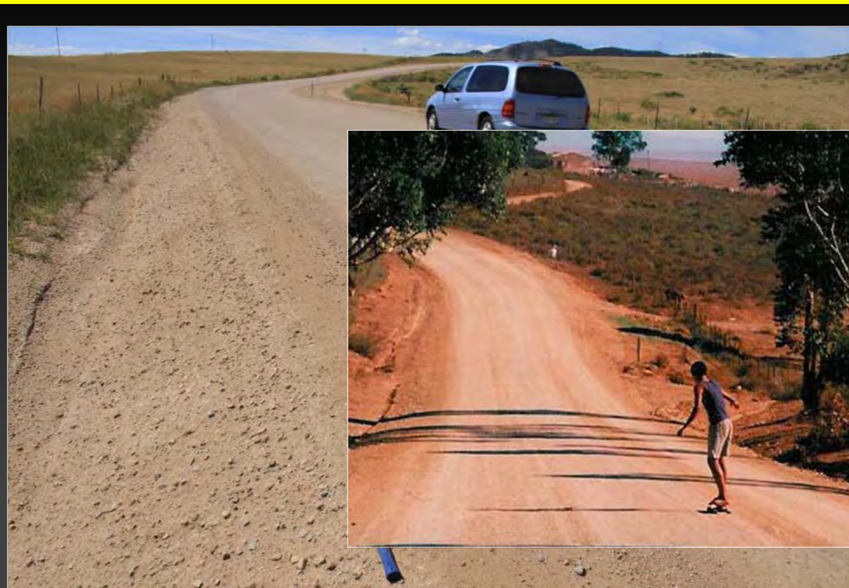
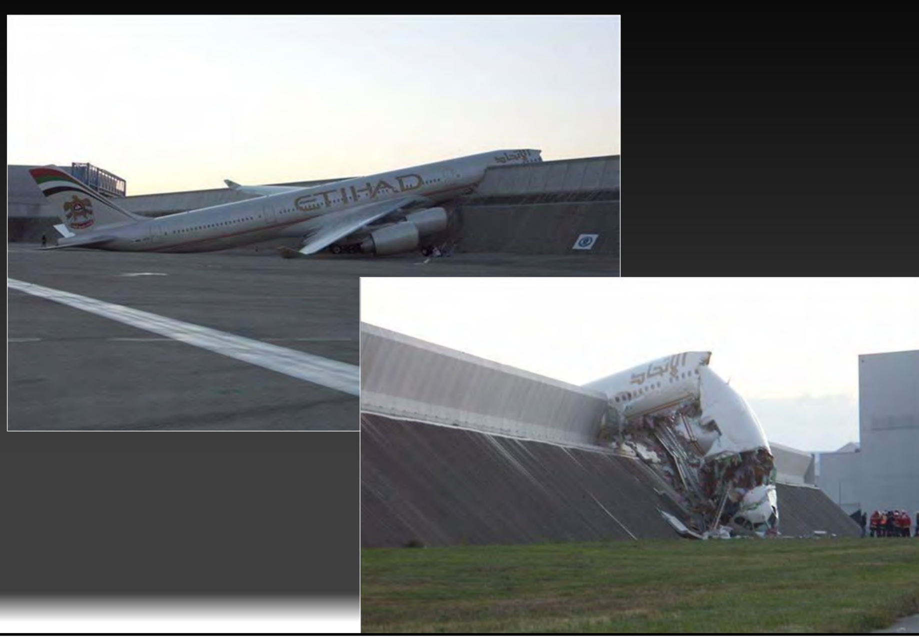
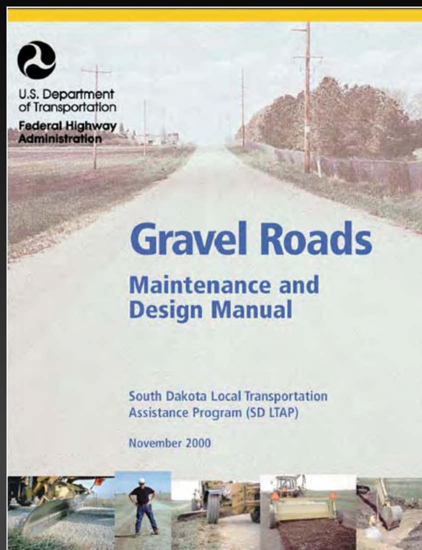
Why Read Guidelines?

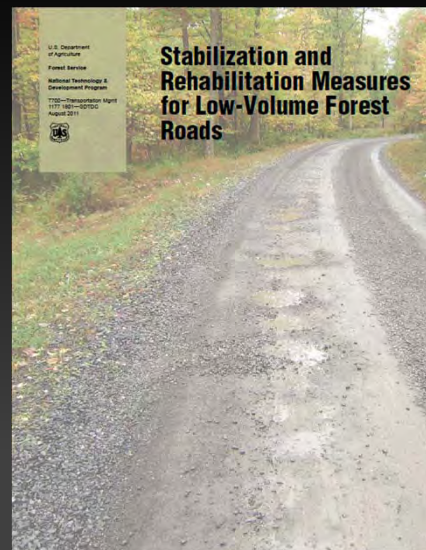


Why Read Guidelines?



Guidelines and Specifications





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Guidelines & Specifications – US

Parameter			Guidelines			FHWA Specification	
			FHWA	USFS		Target	Tolerance
				Haul	General Use		
Sieve (mm. [US])	25	(1)	100	97 – 100	100	100	--
	19	(3/4)	90 – 100	76 – 89	97 – 100	97 – 100	--
	4.75	(#4)	50 – 78	43 – 53	51 – 63	41 – 71	±7
	2.36	(#8)	37 – 67	23 – 32	28 – 39	--	--
	0.425	(#40)	13 – 35	15 – 23	19 – 27	12 – 28	±5
	0.075	(#200)	4 – 15	10 – 16[1] or 6 - 12[1]	10 – 16[1] or 6 - 12[1]	9 – 16	±4
Plasticity Index			4 – 12	2 – 9 if 0.075 is <12% <2 if 0.075 is >12%		8	±4

[1] Range for 0.075 mm (#200) sieve is 6.0 to 12.0% if the PI is greater than 0

Test, don't guess!

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Guidelines & Specifications – SA

Particle size distribution factor (G_c)[1]	15 – 35
Weighted clay factor (S_p)[2]	100 – 365
Maximum size (in.)	1.5 – 2.0
Strength factor (CBR)	>15
Hardness factor (TIV)	20 – 65

[1] $G_C = ((P1 - P\#8)*P\#4)/100$

[2] $S_P = LS*P\#40$ or $\frac{1}{2} PI*P\#40$

** Calibrate for local use, conditions and test methods! Performance is always dependent on construction and maintenance quality!**

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Understanding Performance - USFS

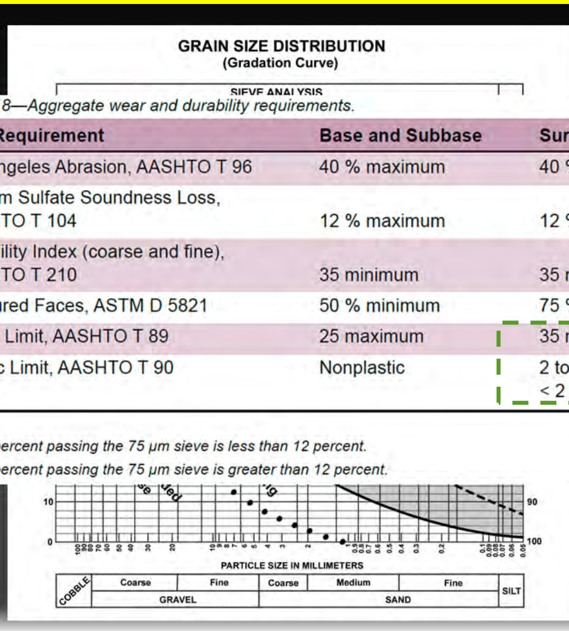

Table 3-18—Aggregate wear and durability requirements.

Test Requirement	Base and Subbase	Surfacing
Los Angeles Abrasion, AASHTO T 96	40 % maximum	40 % maximum
Sodium Sulfate Soundness Loss, AASHTO T 104	12 % maximum	12 % maximum
Durability Index (coarse and fine), AASHTO T 210	35 minimum	35 minimum
Fractured Faces, ASTM D 5821	50 % minimum	75 % minimum
Liquid Limit, AASHTO T 89	25 maximum	35 maximum
Plastic Limit, AASHTO T 90	Nonplastic	2 to 9 (1) ≤ 2 (2)

Note:
(1) If the percent passing the 75 µm sieve is less than 12 percent.
(2) If the percent passing the 75 µm sieve is greater than 12 percent.

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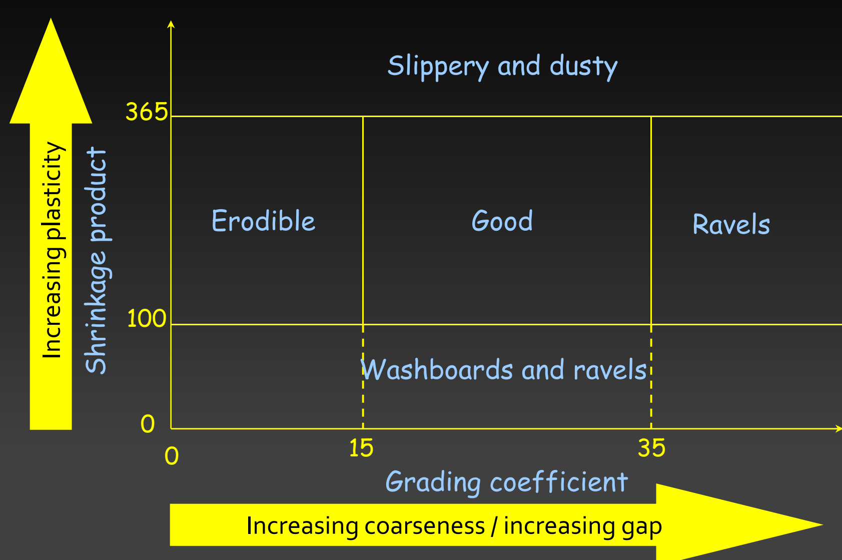
Understanding Performance - SA



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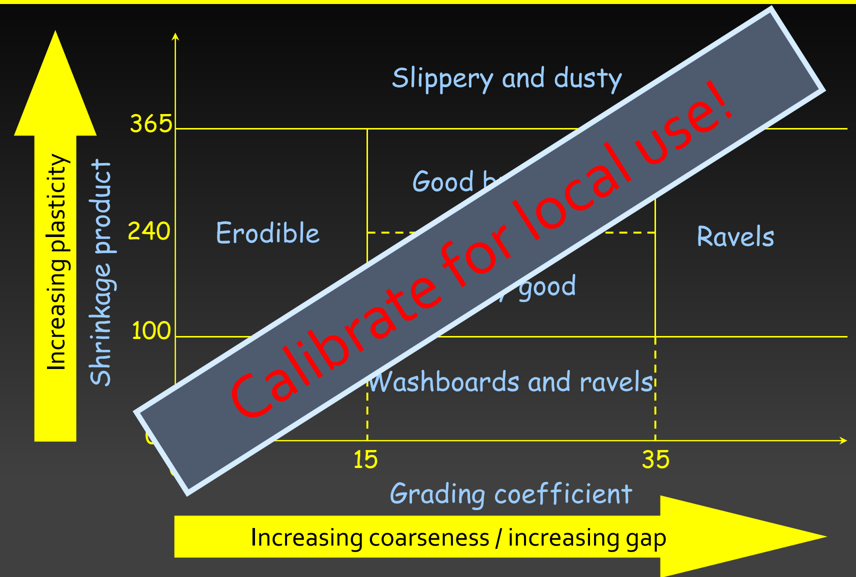
Understanding Performance - SA



Guidelines & Specifications – US

Parameter		FHWA	USFS	
			Haul	General Use
Sieve Size (US)	1 in.	100	97 – 100	100
	#4	50 – 78	43 – 53	51 – 63
	#8	37 – 67	23 – 32	28 – 39
	#40	13 – 35	15 – 23	19 – 27
Plasticity Index		4 – 12	2 – 9 if #200 is <12% <2 if #200 is >12%	
Grading Coefficient: (15 – 35)	High range	26	36	38
	Mid range	31	34	38
	Low range	32	32	37
	Worst case	49	41	45
Shrinkage Product: (100 – 365)	High range	420	207 / 23	243 / 27
	Mid range	192	105	126
	Low range	26	30	38
	Worst case	420	23	27

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Guidelines & Specifications – US

Parameter			FHWA	USFS	
				Haul	General Use
Sieve (mm. [US])	25 4.75 2.36 0.425	(1) (#4) (#8) (#40)	100 50 – 78 37 – 67 13 – 35	97 – 100 43 – 53 23 – 32 15 – 23	100 51 – 63 28 – 39 19 – 27
Plasticity Index			4 – 12	2 – 9 if 0.075 is <12% <2 if 0.075 is >12%	
Grading Coefficient: (15 – 35)		High range Mid range Low range Worst case	26 31 32 49	36 34 32 41	38 38 37 45
Shrinkage Product: (100 – 365)		High range Mid range Low range Worst case	420 192 26 420	207 (23 105 30 23	243 (27 126 38 27

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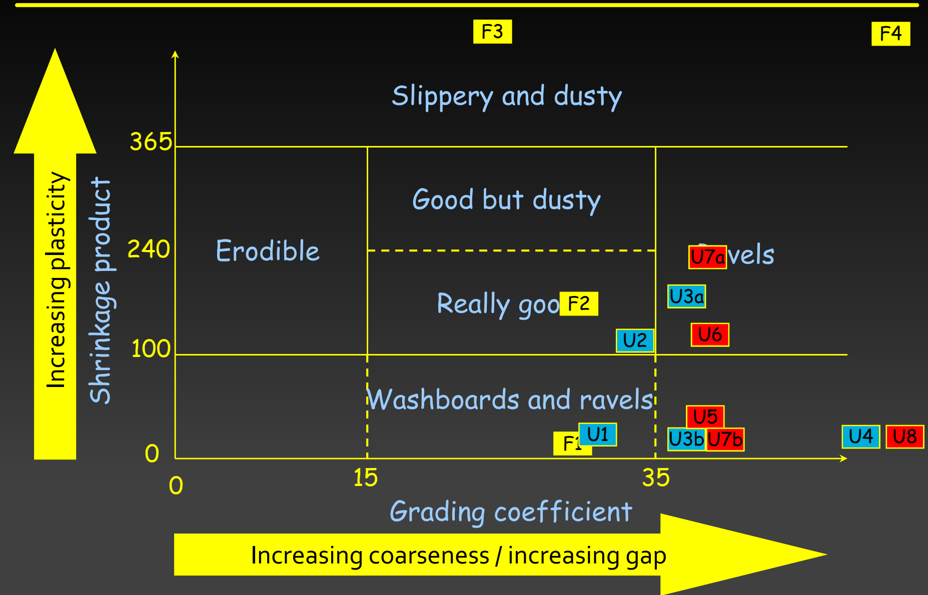
Performance Prediction



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Discussion

- Materials that meet US federal guidance and specifications may still perform badly
  - Only two of the 14 potential in-spec materials are likely to perform well
  - Most materials are likely to washboard and ravel
  - Some materials are likely to be slippery/ impassable when wet
  - Problematic for inexperienced engineers
  - Aggregate suppliers and contractors still meet the spec
- Importance of using PI (weighted) and grading together is clear

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Discussion

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Summary

- Current US specs and guidance can be misleading
- Use a simple analysis tool for understanding unpaved road material performance
  - Proven to be effective in Africa, Australasia, S.E. Asia, and USA
- Use any specification, but understand performance
  - Select the best possible material
  - Blend
  - Construct properly
  - Change maintenance program
  - Improve with chemicals
- Testing is <u>not</u> expensive and will save money

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Thank-you

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MAKING BETTER GRAVEL ROADS PART 2: CHEMICAL TREATMENTS AS PART OF A ROAD MANAGEMENT STRATEGY

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[1] *University of California Pavement Research Center*

County Engineers Association of California

2016 Bedroll Conference, August 9, 2016

UCPRC UNIVERSITY of CALIFORNIA Davis • Berkeley PAVEMENT RESEARCH CENTER


الغبار قاتل !
أترك مسافة كافية أمامك
DUST KILLS!
Keep your distance
TOYOTA
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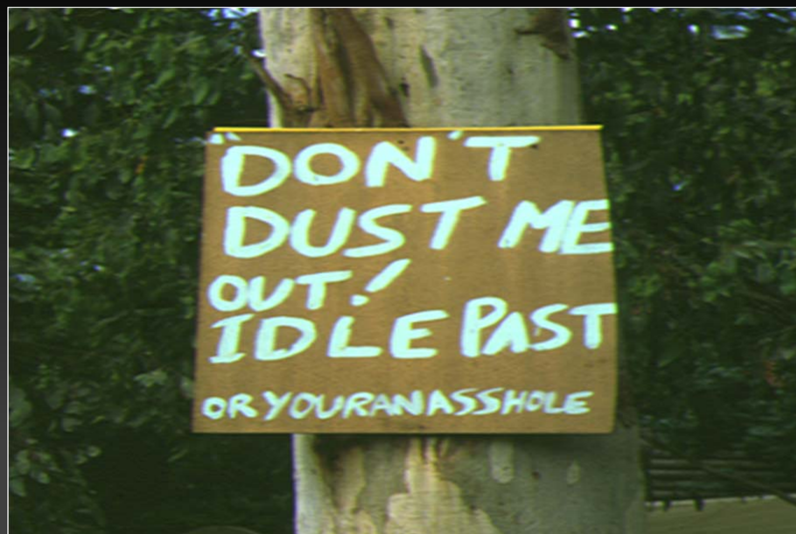
Australian Version



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Outline

- Introduction
- Status quo
- Additive categories
- Additive selection
- Summary

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Introduction

- Gravel road problems
  - Fines loss (dust)
  - Wet weather passability
  - Safety
  - Environment
- Recommended approach
  - Focus on addressing above issues
  - Start with building the best possible road
  - Use chemical treatments to keep a good road good
  - Set up a simple GRMS
  - Justify approach through extended life of road and reduced maintenance

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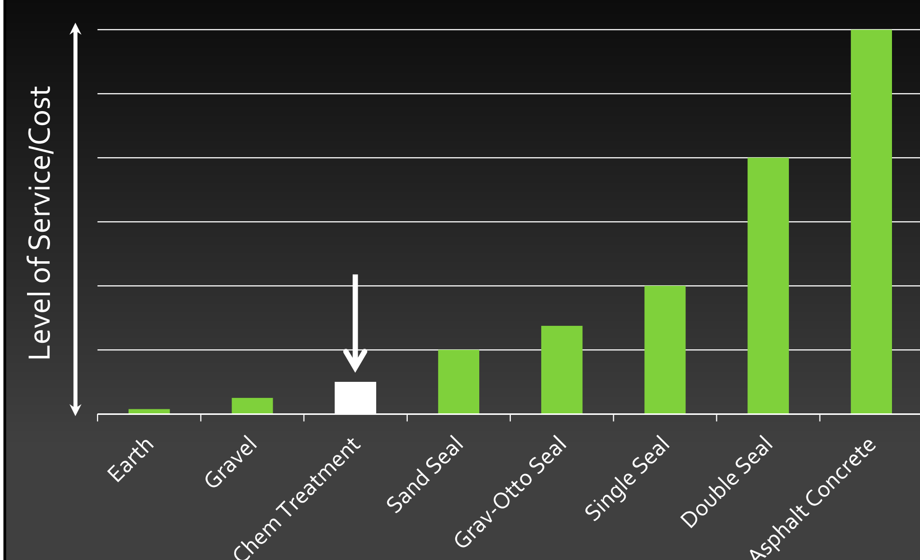
Role of Chemical Treatments



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Outline

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Status Quo

- Timeline for road additive development
  - Chlorides since 1907
  - Lignosulfonates since 1913
  - Other organic non-petroleum and petroleum products since the 1930's
  - Electrochemicals since 1970's
  - Enzymes and synthetic polymers since 1980's
  - Synthetic fluids and mineral oils since 1990's

Status Quo

- Research and implementation
  - US Forest Service
  - US Army Corps of Engineers
  - Other US
  - International
- Where are we after 110 years?
  - Fragmented industry selling mostly proprietary products
  - No specifications
  - Poor track record/skepticism

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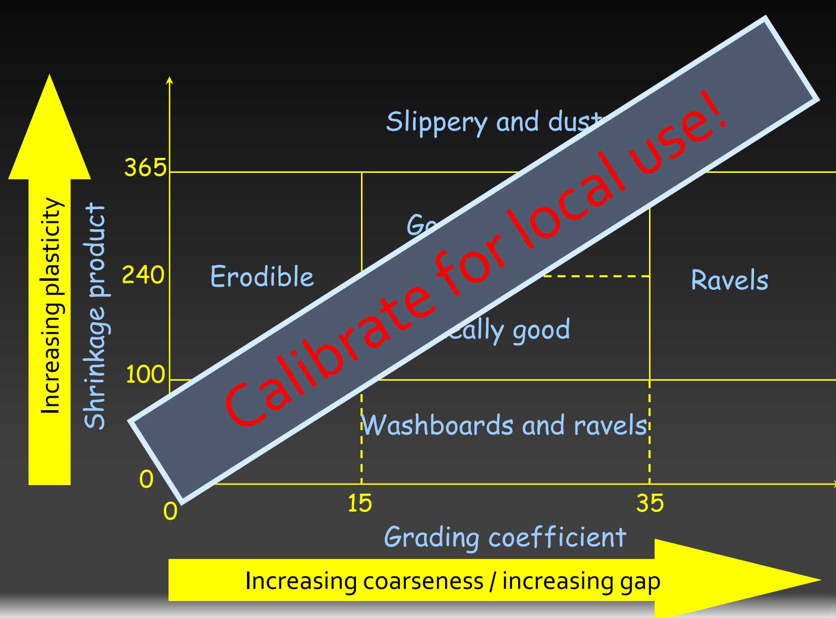
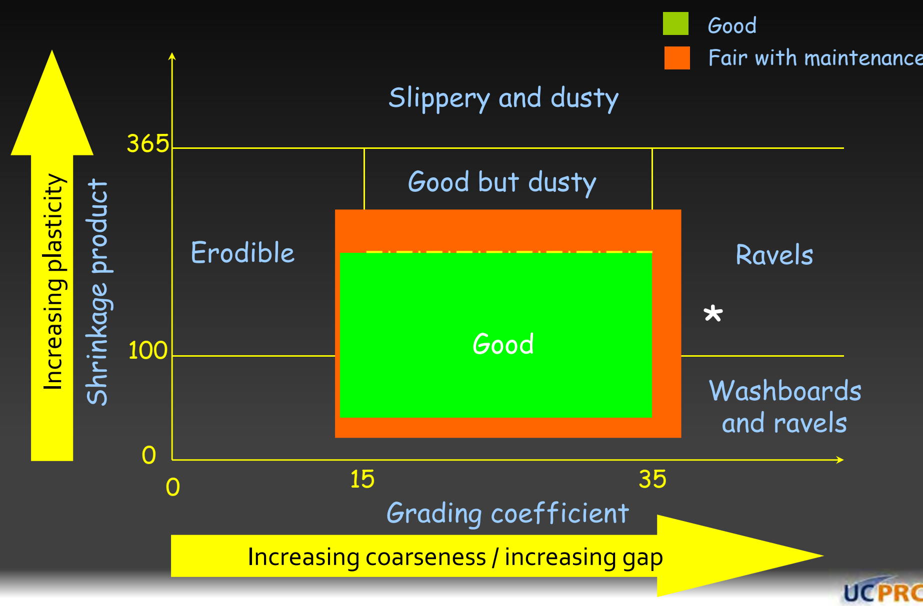
Additive Categories

- Fines retention/surface stabilization
  - Water and water with surfactants
  - Water absorbing
  - Organic non-petroleum or natural polymers
  - Organic petroleum
- Stabilization/strength improvement
  - Organic petroleum
  - Synthetic polymer emulsions
  - Concentrated liquid stabilizers

Performance Prediction



Water Absorbing



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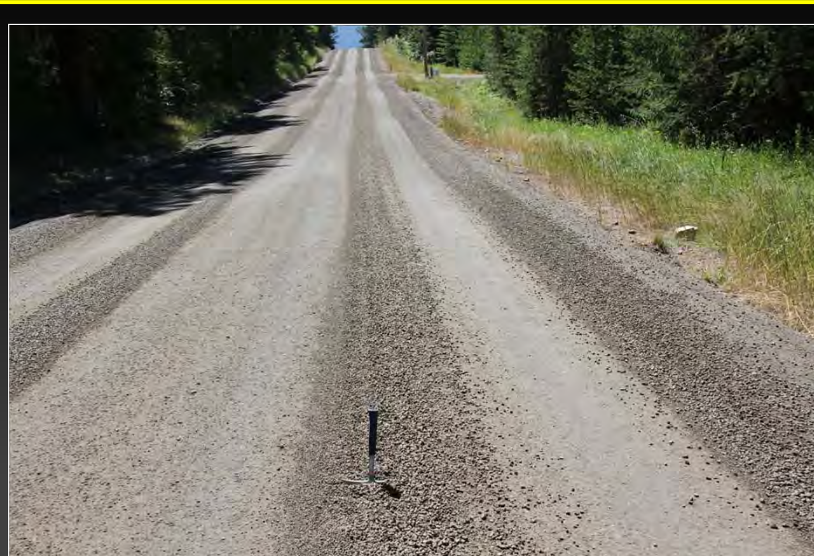
Water Absorbing



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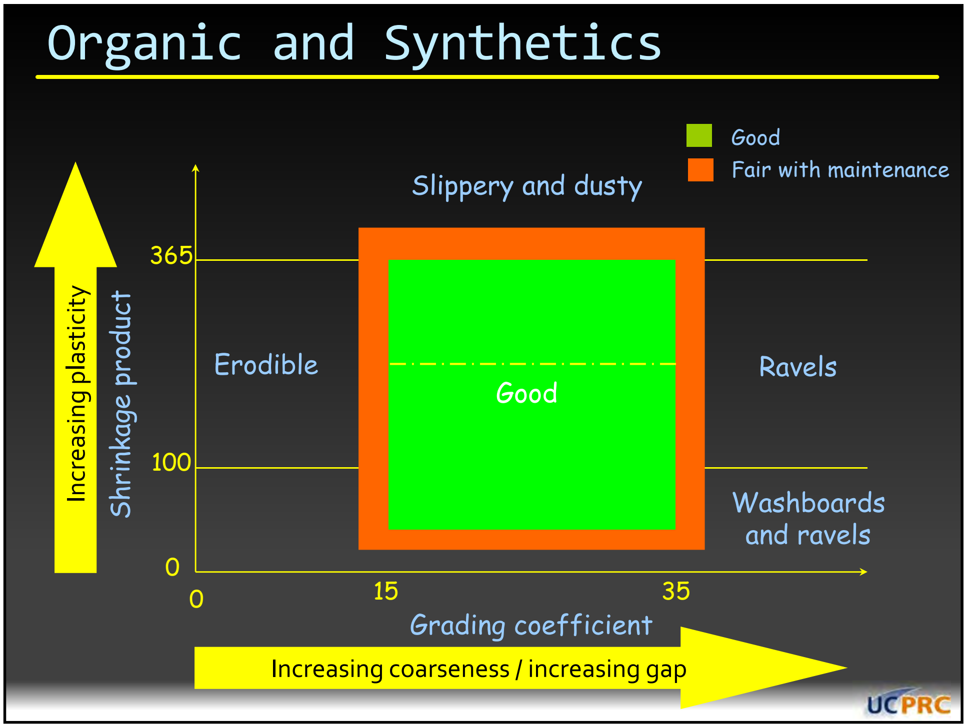
Organic and Synthetics
Good
Fair with maintenance
Slippery and dusty
365
Erodible
Good
Ravels
Increasing plasticity
Shrinkage product
100
Washboards and ravels
0
0
15
35
Grading coefficient
Increasing coarseness / increasing gap
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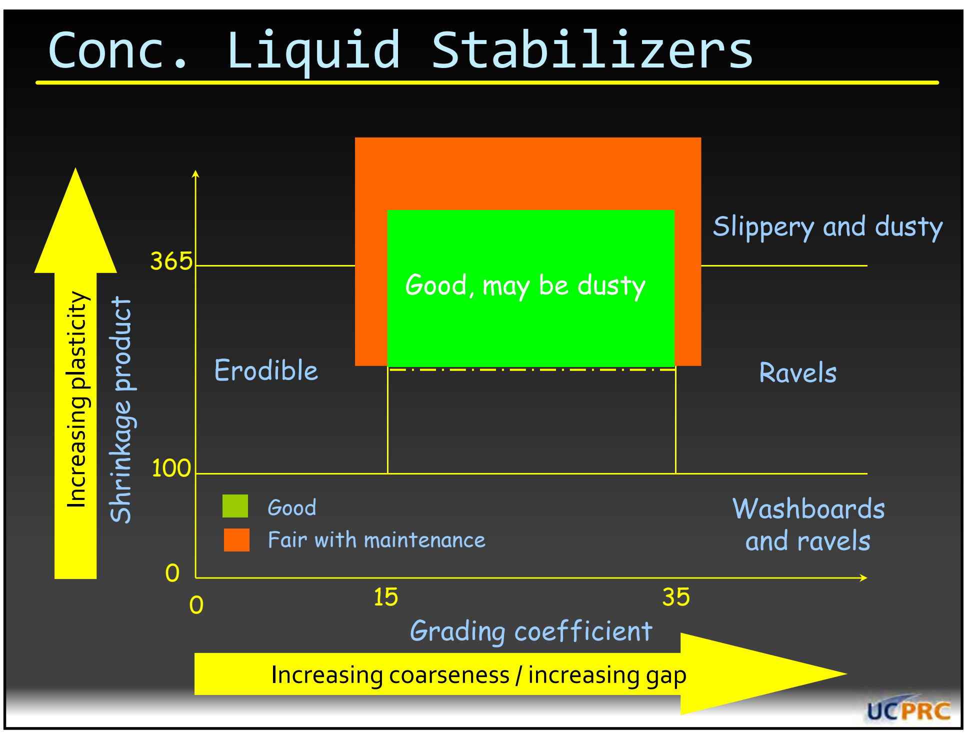
Conc. Liquid Stabilizers
Slippery and dusty
365
Good, may be dusty
Erodible
Ravels
Increasing plasticity
Shrinkage product
100
Good
Fair with maintenance
Washboards and ravels
0
0
15
35
Grading coefficient
Increasing coarseness / increasing gap
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Current Practice

- Currently based on:
  - Experience
  - Guides
    - US Forest Service Guide (1999)
    - US Army Corps of Engineers
    - FPInnovations (Canada)
    - FHWA
  - Preferred lists
  - Marketing by suppliers

Background

- 1999 US Forest Service Guide
- New developments since 1999
  - More products (±200 in USA)
  - More/refined categories
    - Dust control vs. stabilization
  - Additional experience
    - Documented field trials
  - Requests for more detailed guidance, preferably with ranking

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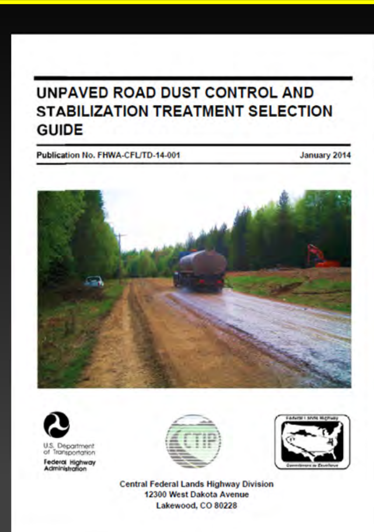
New FHWA (UCPRC) Guide

- Ten-step process
- Have a clear objective
  - Temporary dust control
  - Long-term fines preservation
  - All weather passability
  - Unpaved road management
    - Reduced maintenance
    - Extended gravel replacement intervals
- Manual, spreadsheet, and web-based
- Focused on keeping a good road good



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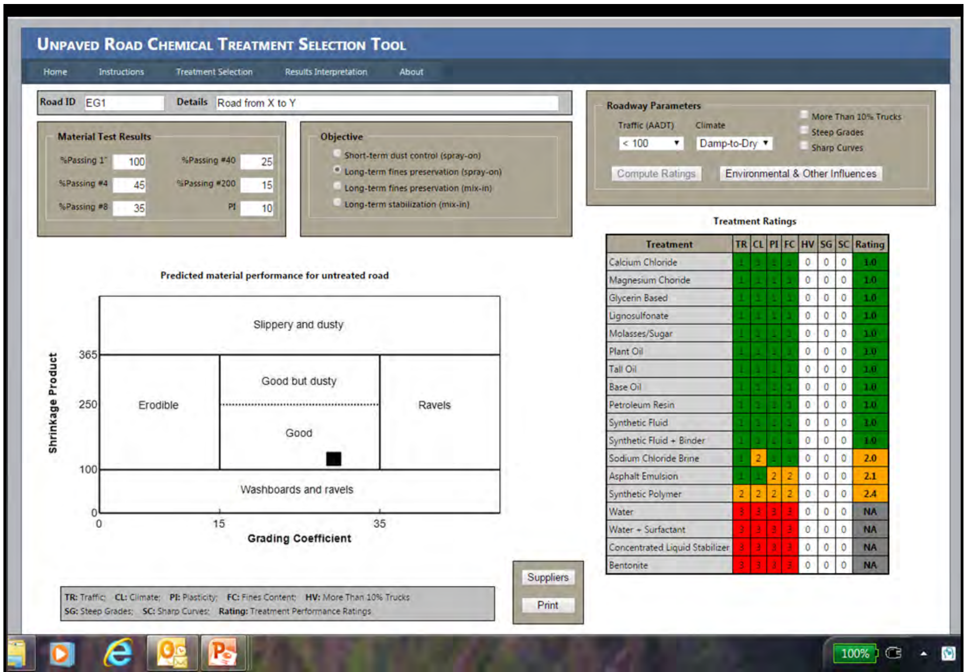
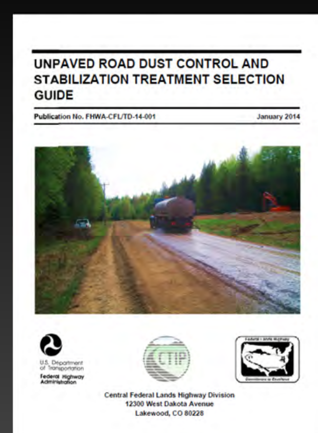


Treatment Selection Tools

- Specifications
  - Example specification language to cover all product sub-categories in terms of procurement, environmental and application
- Based on certificate of compliance for procurement
  - Sub-category
  - Verifications
    - Meets category specifications
    - Safety data sheet
    - Environmental requirements
- Use as basis for QC/QA



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Example Spec Language

Example Provisional Specification: Calcium Chloride Solution[1]		
Clear odorless liquid intended for fines preservation, dust control and/or stabilization of unpaved roads. It has the following properties it its undiluted state.		
Test Parameter	**Suggested Acceptance Limits**	**Suggested Test Method**
Calcium chloride content	28 – 42%	ASTM E449
Total magnesium as $MgCl_2$	< 6.0%	ASTM E449
Total alkali chlorides as NaCl	< 6.0%	ASTM E449
Calcium hydroxide content	< 0.2%	ASTM E449
pH (5% solution)	7.0 – 9.0	ASTM D1293
Specific gravity	1.28 – 1.44	ASTM D1429

Notes
[1] ASTM D98/AASHTO M144

Example Provisional Specification: Lignosulfonate: Calcium		
Dark brown lignin-based liquid or powder with woody odor derived from the wood pulping using the sulfite process used in the manufacture of cellulose products and designed for fines preservation, dust control and/or stabilization of unpaved roads. It has the following properties it its undiluted/undissolved state.		
Test Parameter	**Suggested Acceptance Limits**	**Suggested Test Method**
Lignin sulfonate content (ready to use)	> 25%	ASTM D4900
Residue (total solids content)	≥ 52%	ASTM D4903/D2834
Lignin sulfonated content of residue	> 50%	-
Reducing sugars content of residue	> 25% of dry weight	ASTM D5896/D6406
pH	6.0 – 9.0	ASTM D1293
Specific gravity	≥ 1.20	ASTM D1429
Absolute viscosity (Brookfield)	< 1,000 cP @ 77°F (25°C)	ASTM D2196

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Summary

- Huge selection of additives
- There are no wonder products
- Select treatment based on
  - Problem/objective/capability
  - Traffic, climate and materials
  - Cost-benefit
  - Vendor credibility
- Understand performance
- Apply and maintain appropriately
- Testing is <u>not</u> expensive and will save money!

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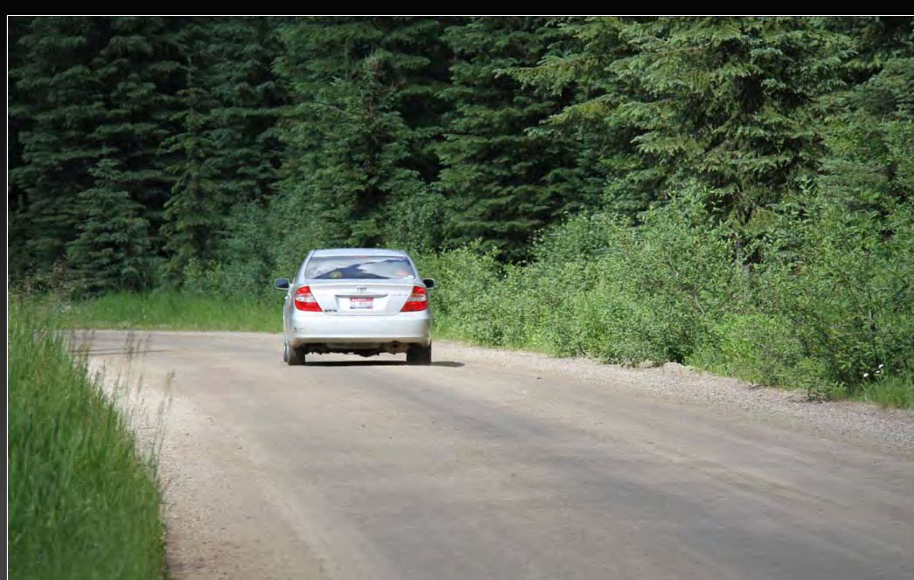

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