BEST PRACTICES FOR SELECTING, SPECIFYING AND USING CHEMICAL TREATMENTS ON UNPAVED ROADS

David Jones PhD

University of California Pavement Research Center

Davis, California

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UNIVERSITY of CALIFORNIA Davis • Berkeley | PAVEMENT RESEARCH CENTER

Dust Kills (People and Roads!)

Or in Australia...

Outline

- Introduction
- Unpaved roads
- Additive categories
- Additive selection
- Specifications
- Summary

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Introduction

- Unpaved roads
  - Role
  - Problems
  - Questionable sustainability
  - Safety and environmental concerns
- Range of management issues primarily funding and limited unpaved road engineering expertise in general
- Chemical treatments will not make a bad road good, they will only keep a good road good

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Introduction

- Unpaving:
  - Many rural paved roads have "evolved" from gravel roads, with limited engineering during the evolution
  - Many should not have been paved to start with
- "Upgrading" to engineered unpaved is an option
  - But seen as going backwards
    - "I pay taxes, why don't you just pave it properly!"

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Outline

- Introduction
- **Unpaved roads**
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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 it good
  - Set up a simple GRMS
  - Justify approach through extended life of gravel and reduced maintenance

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Guidelines

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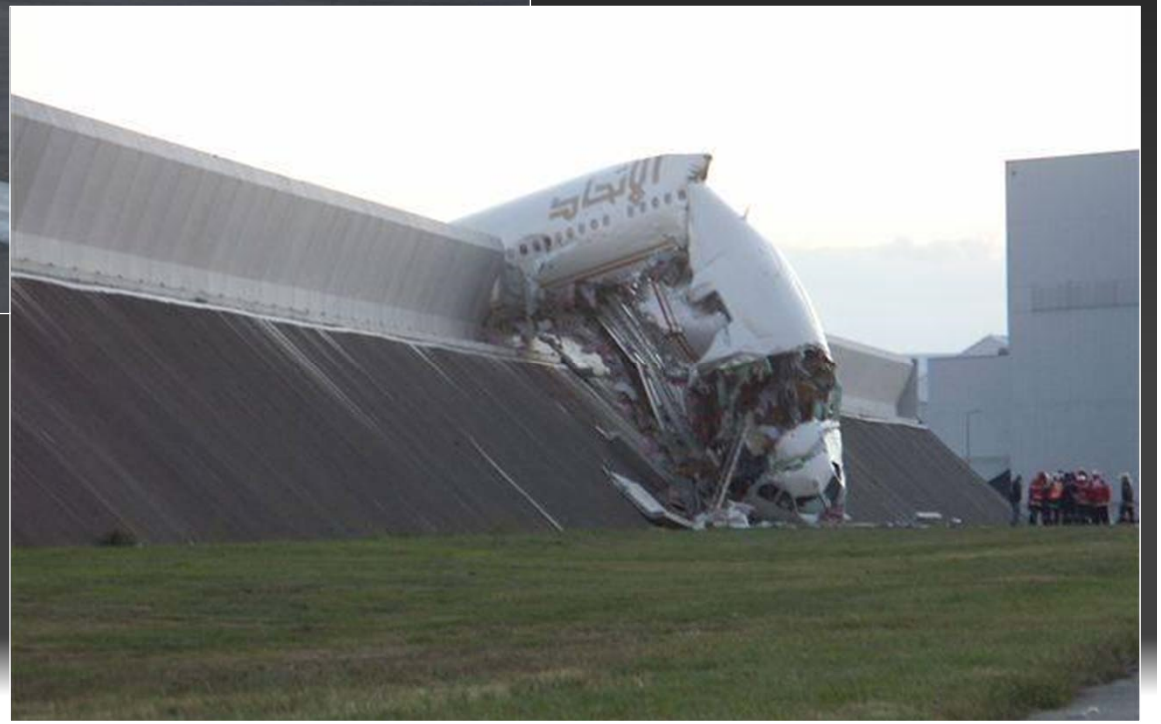
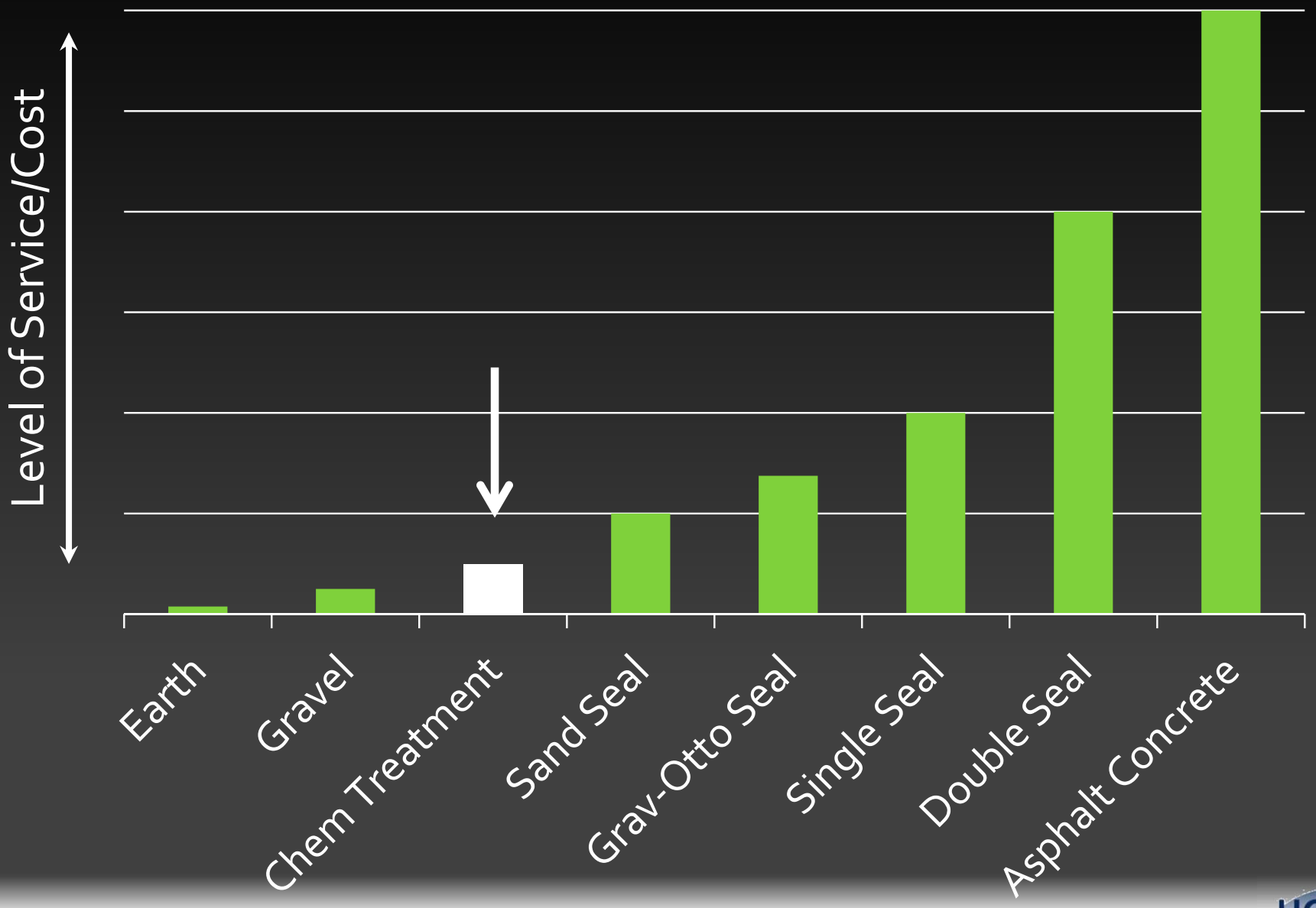
Guidelines?

Why Read Guidelines?

Why Read Guidelines?



Role of Chemical Treatments



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Kootenai National Forest, MT

Outline

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Additive Categories

- Two main groups of chemical treatment
  - Surface stabilizers to control fines loss (dust control)
  - Full-depth stabilizers for improving passability, preserving material, and dust control
  - Various categories and sub-categories within each group

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Additive Categories

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

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Water & Water with Surfactants

- Most commonly used
- Usually most expensive
  - Short-term effect
  - Water may be "free", application is not
  - Accelerated road deterioration
    - Pumping of fines
    - Erosion
    - Potholes
  - Social impacts
  - Environmental impacts

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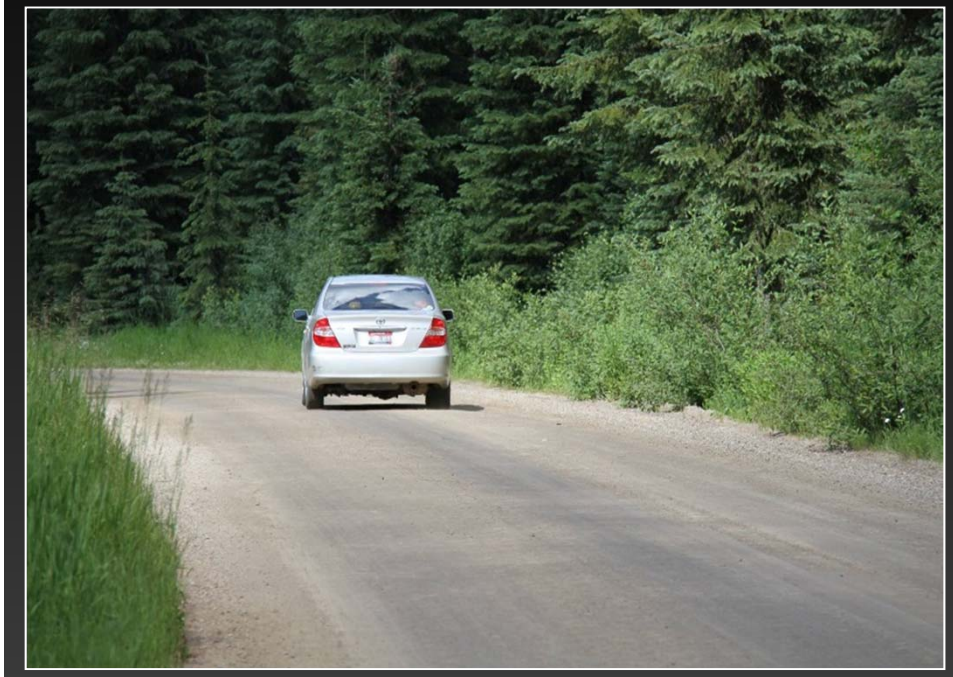
Water Absorbing

- Magnesium, calcium, and sodium chloride



Organic Non-Petroleum

- Glycerin based, lignosulfonate, molasses, plant oils (soy, canola, palm, corn, etc.), rosins, tall oils

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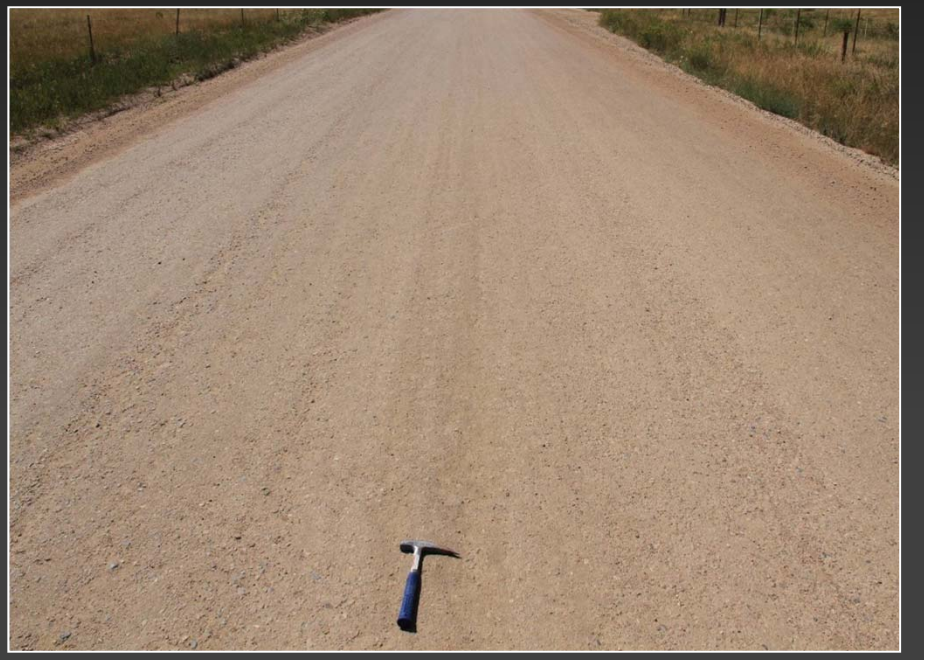
Organic Petroleum

- Bitumen emulsions, base / mineral oils, petroleum resins, synthetic fluids, waxes, etc.

Organic Petroleum

Synthetic Polymer Emulsions

- No official subcategories, but generally includes acrylates, latexs, PVCs, PVAs, SBS, etc.



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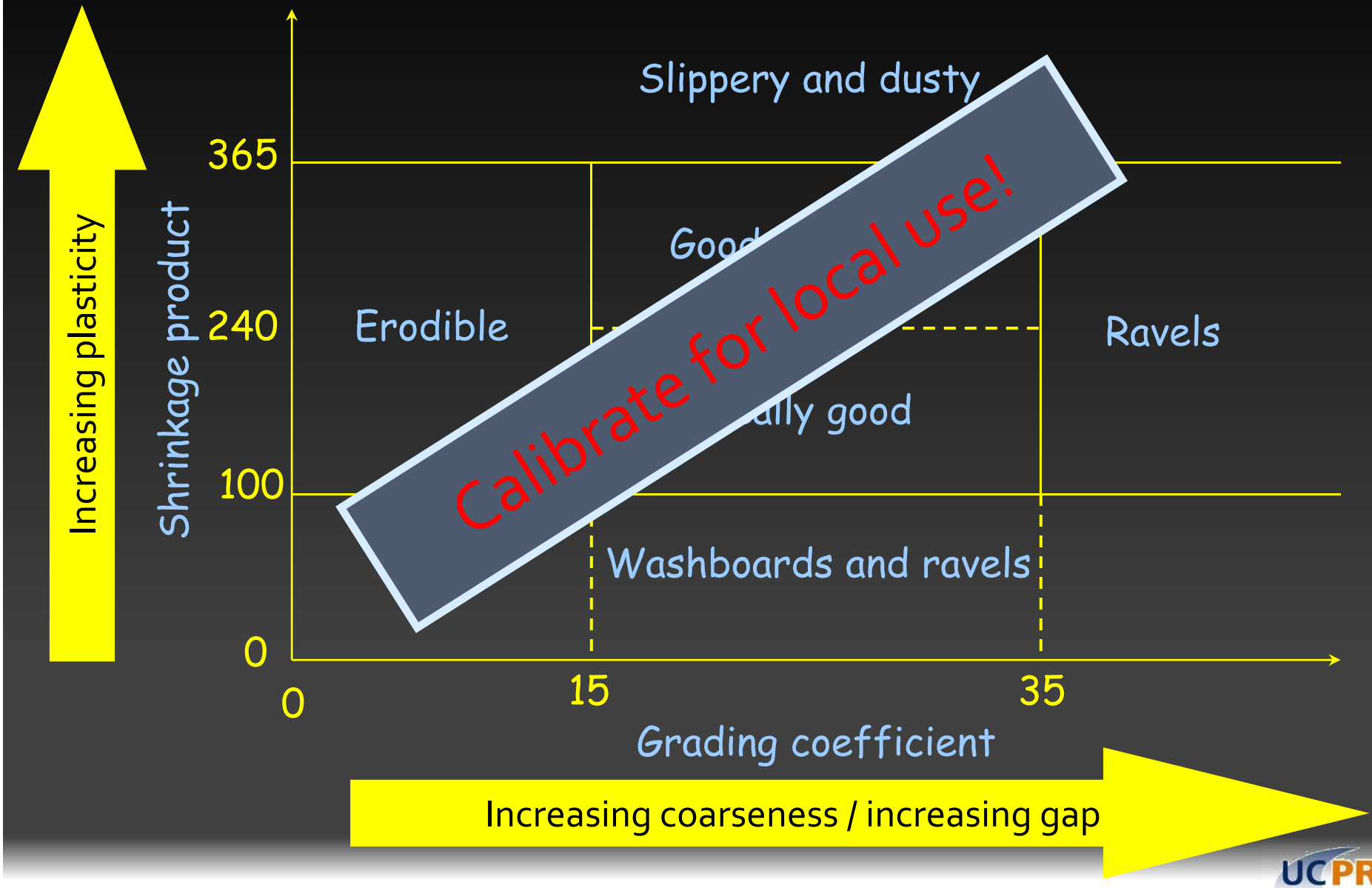
Concentrated Liquid Stabilizers

- High acidity (sulfonated oils, ionic stabilizers) and low/neutral acidity (enzymes)
- Chemical reaction with soil
  - "Waterproofs" clay minerals
  - Compaction aid
- Limitations
  - Must be applied as mix-in
  - Dependent on soil chemistry
  - Can be difficult to maintain
  - May require additional dust control

Performance Prediction



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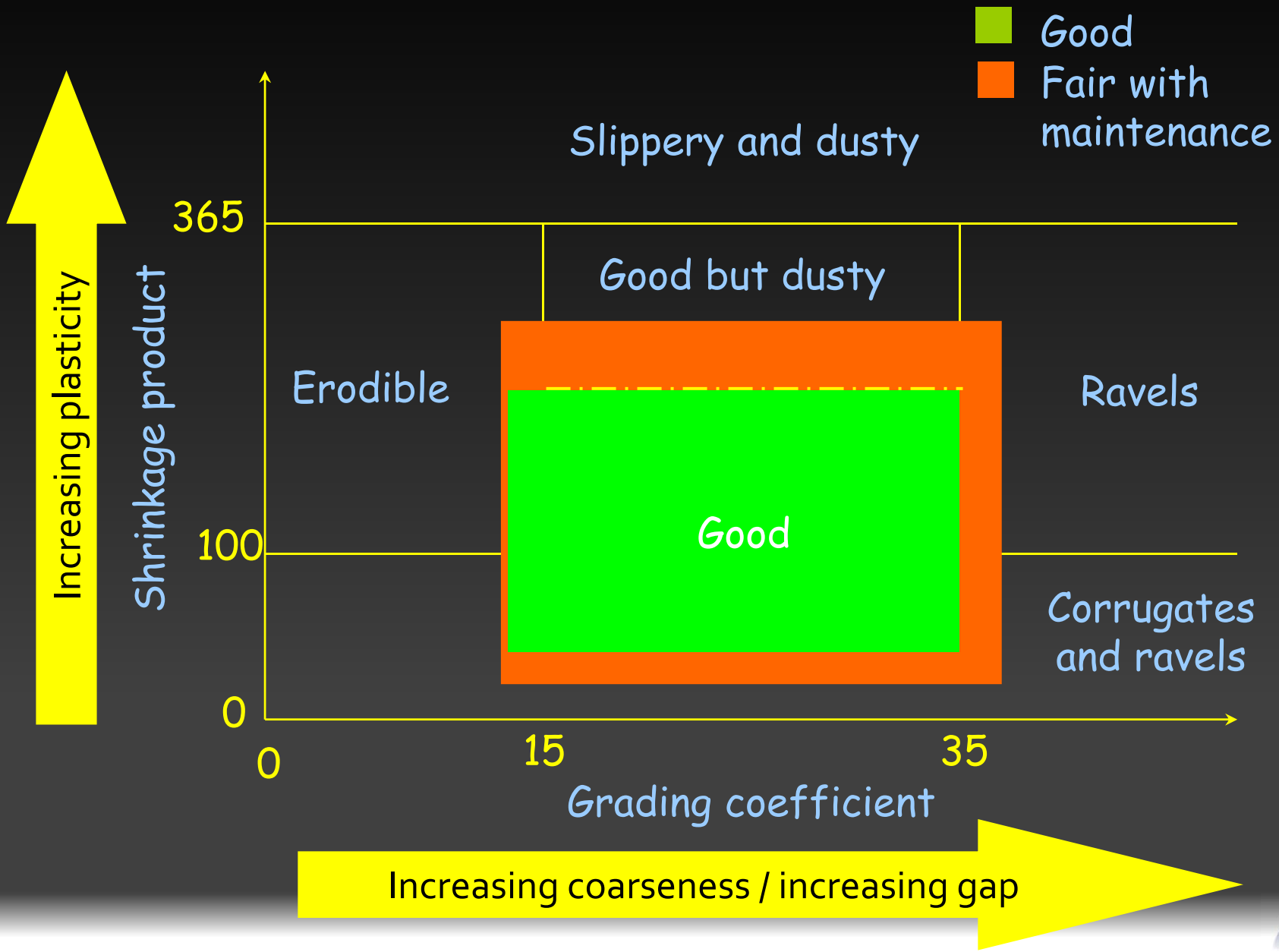
Water Absorbing



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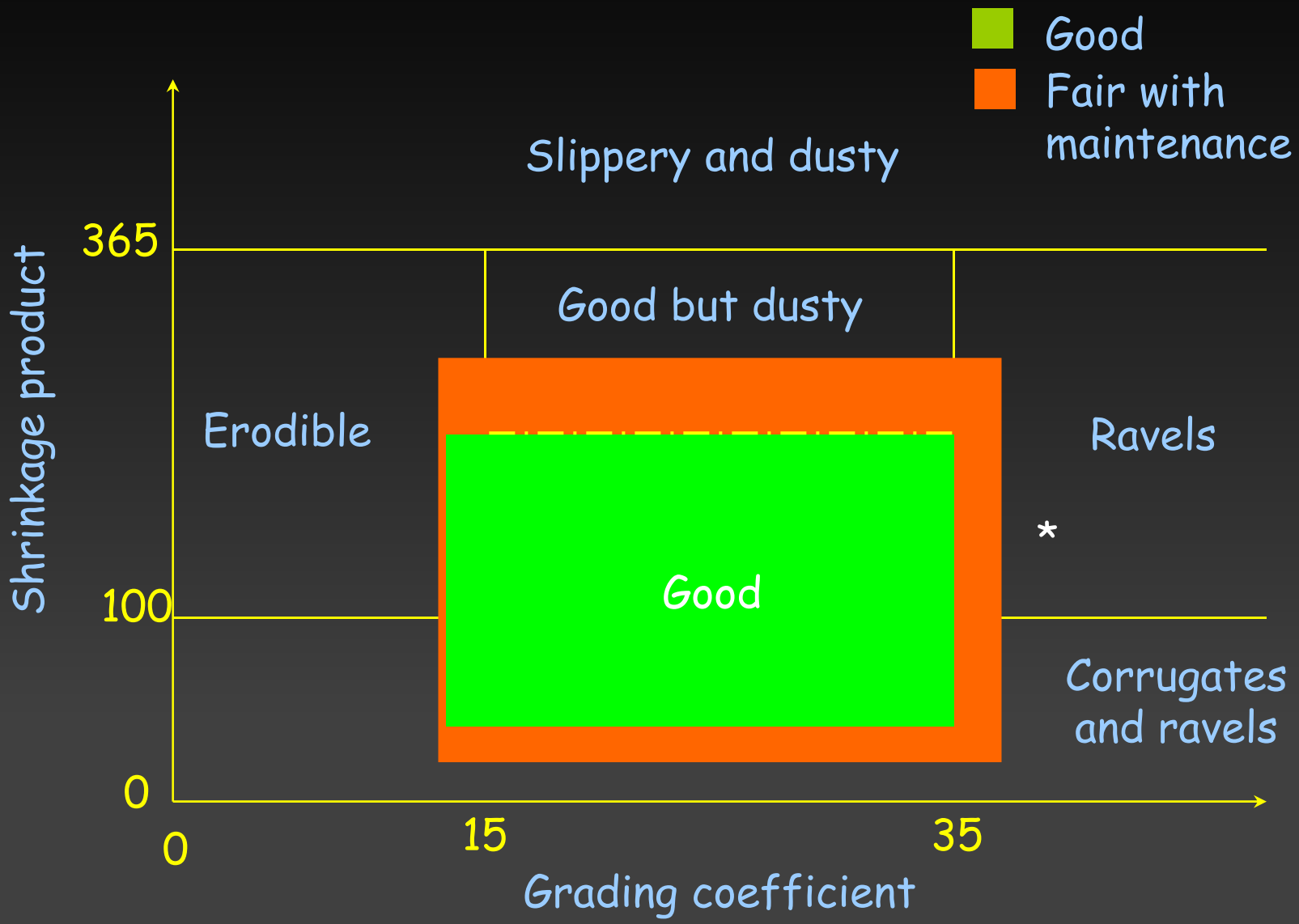
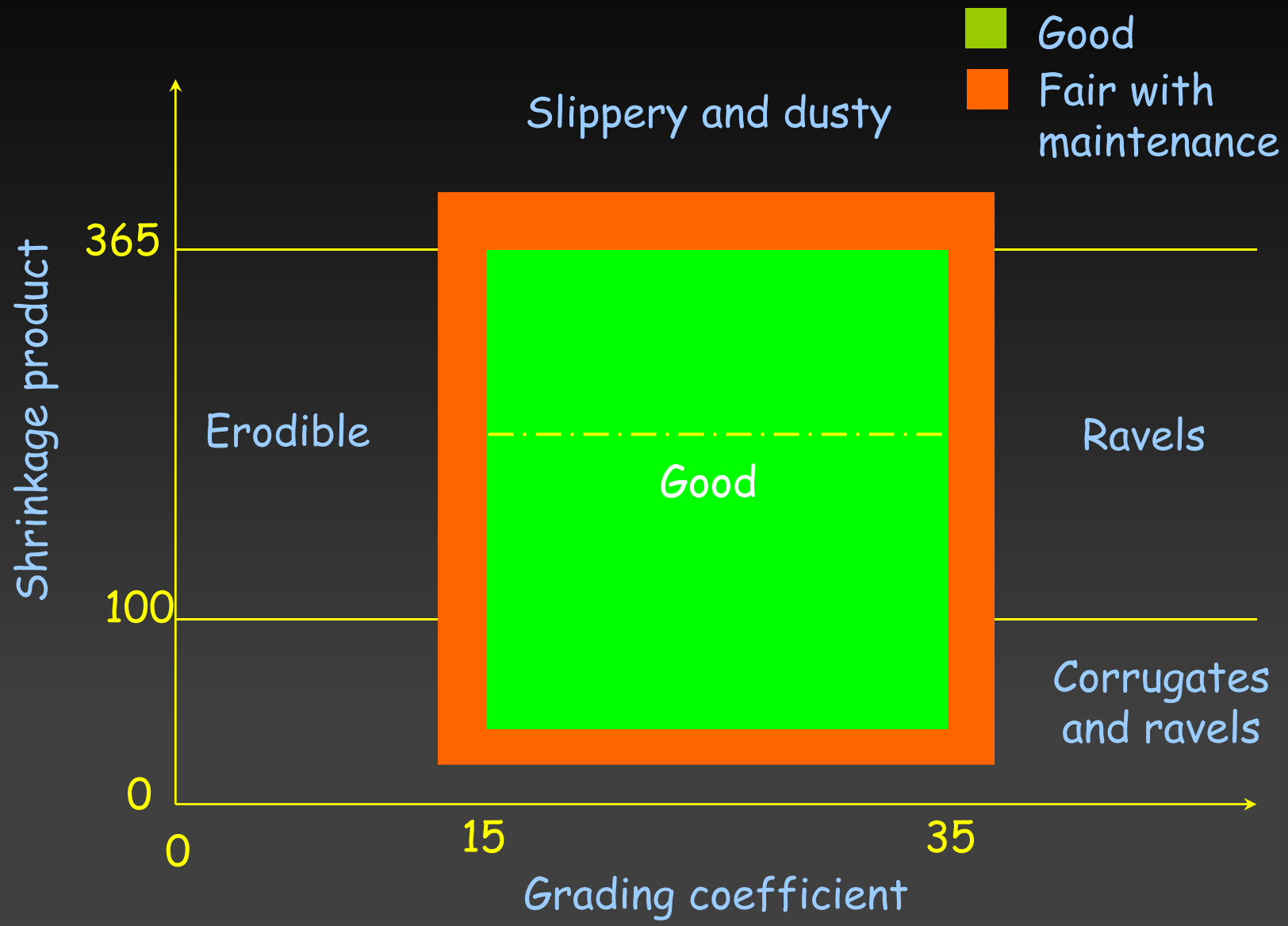
Water Absorbing

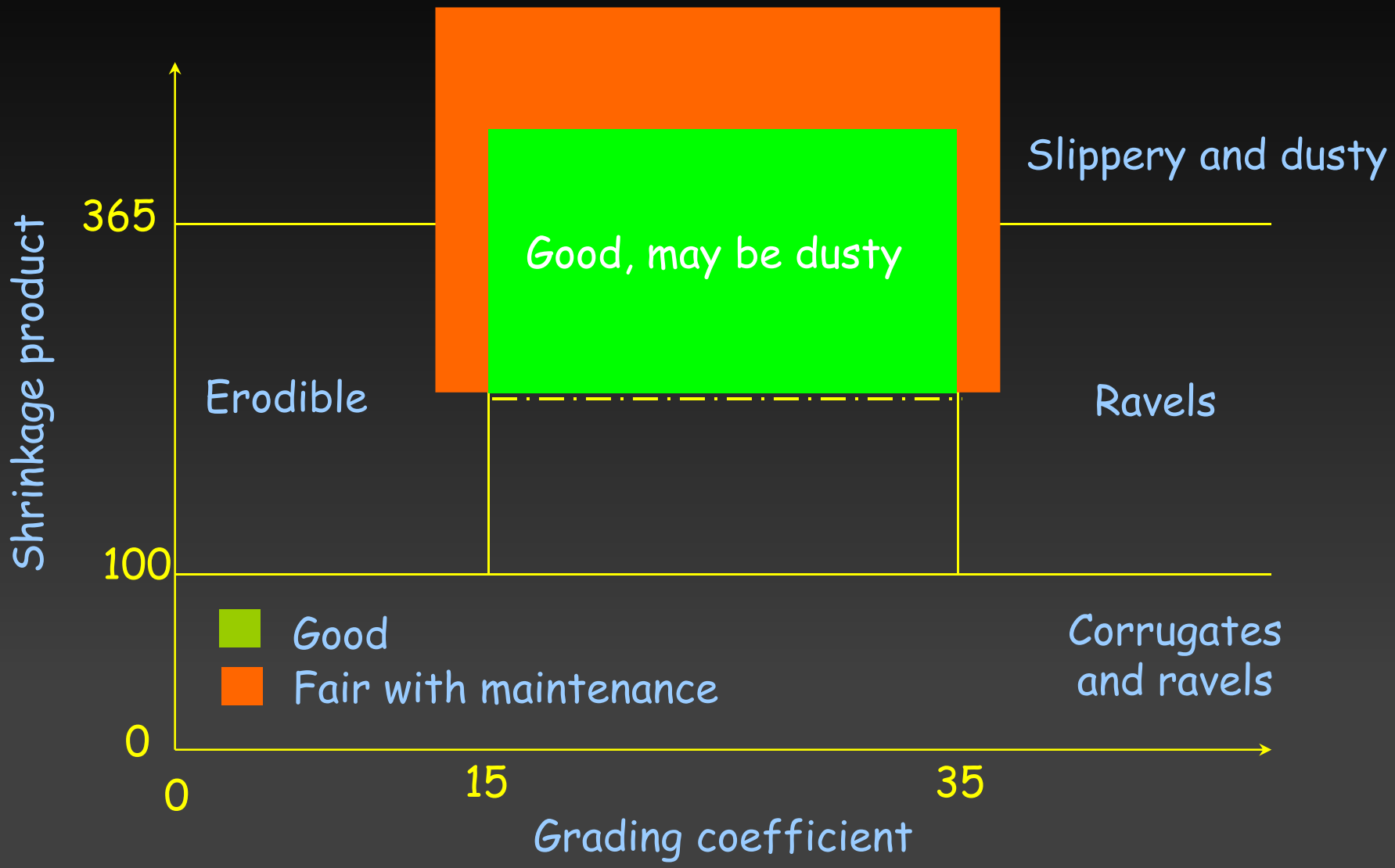


Water Absorbing

Organic and Polymer Emulsions



Conc. Liquid Stabilizers



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Current Practice

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

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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 Guides

- Ten-step process, based on approach of "keeping a good road good"
- Start with a clear objective
  - Temporary dust control
  - Long-term fines preservation
  - All weather passability
  - Unpaved road management
    - Reduced maintenance
    - Extended gravel replacement intervals

Additive Selection

- Step 1: Review experience
- Step 2: Understand road and road materials
- Step 3: Set objective
- Step 4: Select traffic and climate categories
- Step 5: Select plasticity index and fines content
- Step 6: Consider road geometry
- Step 7: Calculate performance / rank for selection
- Step 8: Understand environmental impacts
- Step 9: Understand other limitations
- Step 10: Do performance testing

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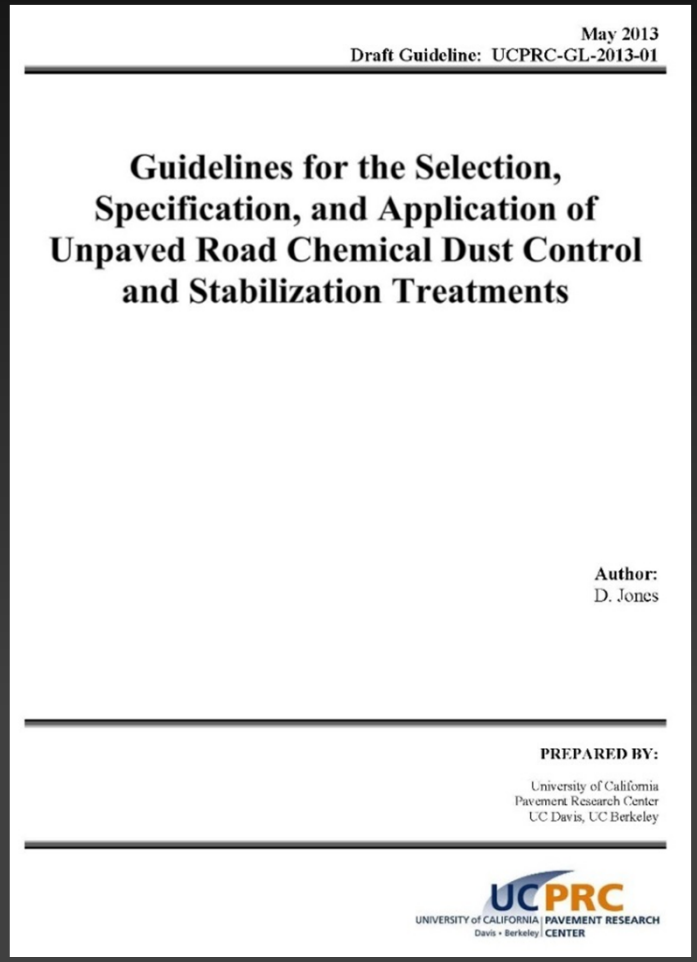
Treatment Selection Tools

- Manual using forms in guide
- Spreadsheet (FHWA version)
- Web-based (UCPRC version)



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What's in the Blackbox?

Additive Category/ Sub-Category	Traffic			Climate			Wearing Course Material								
	Average Daily Traffic			Humidity/Storm Intensity			Plasticity Index				Fines (% Passing #200 [75 µm] Sieve)				
	<100	100-250[1]	>250[1]	Dry[2]	Damp	Wet[3,4,5]	<3[6]	3-5[6]	6-15	>15[5,7]	<5[1]	5-10[1]	11-20	21-30[7,8]	>30[5,7,8]
Water and Water plus Surfactant															
Water	Not cost effective as a long-term fines preservation strategy														
Water + surfactant	Not cost effective as a long-term fines preservation strategy														
Water absorbing															
Calcium chloride	1	1	7	50[9]	1	50[10]	7	1	1	50	50	7	1	7	50
Magnesium chloride	1	1	7	7[9]	1	50[10]	7	1	1	50	50	7	1	7	50
Sodium chloride brine	1	7	50	50[9]	7	50[10]	50	1	1	50	50	7	1	7	50
Organic Non-Petroleum															
Glycerin based	1	7	50	1	1	50	7	1	1	50	50	7	1	7	50
Lignosulfonate	1	1	7	1	1	50	7	1	1	50	50	7	1	1	7
Molasses/sugar	1	50	50	1	1	50	50	1	1	50	50	50	1	7	50
Plant oil	1	7	50	1	1	50	50	1	1	50	50	7	1	1	50
Tall oil pitch resin	1	7	50	1	1	7	7	1	1	50	50	7	1	1	50
Organic Petroleum															
Asphalt emulsion	1	7	50	1	1	7	7	1	7[8]	50	7	1	7[7]	50	50
Base oil	1		7	1	1	7	7	1	1	50	50	7	1	1	50
Petroleum resin	1	7	50	1	1	7	7	1	1	50	7	7	1	7	50
Synthetic fluid	1	1	7	1	1	7	7	1	1	50	50	7	1	1	7
Synthetic fluid + binder	1	1	7	1	1	7	7	1	1	50	50	7	1	1	7
Synthetic Polymer Emulsion															
Synthetic polymer[11]	7	7	50	7	7	7	7	7	7	50	50	7	7	50	50
Conc. Liquid Stabilizer															
Conc. Liquid Stabilizer	Not suitable as a spray-on fines preservation/dust control treatment														
Clay Additive															
Bentonite	Not suitable as a spray-on fines preservation/dust control treatment														

Additive Category/ Sub-Category	% trucks	Geometry	
	>10[1]	Steep Grades[4,5]	Sharp Curves[1,5]
Water	Not cost effective as a long-term fines preservation strategy		
Water + surfactant	Not cost effective as a long-term fines preservation strategy		
Calcium chloride	1	7	7
Magnesium chloride	1	7	7
Sodium chloride brine	1	7	7
Glycerin based	1	7	7
Lignosulfonate	1	7	7
Molasses/sugar	7	7	7
Plant oil	7	7	7
Tall oil pitch resin	1	7	7
Asphalt emulsion	50	1	7
Base oil	7	1	1
Petroleum resin	1	1	7
Synthetic fluid	1	1	1
Synthetic fluid + binder	1	1	1
Synthetic polymer	7	7	7
Conc. Liquid Stabilizer	Not suitable as a spray-on fines preservation treatment		
Bentonite	Not suitable as a spray-on fines preservation treatment		

Key to Colors and Explanation Notes in Selection Charts	
1	No significant influence on performance
7	Some influence on performance
50	Significant influence on performance

1 Cars and trucks at higher speeds may break surface crust and accelerate washboarding and raveling, if so more frequent rejuvenation will be required
2 More than 20 days with less than 40% relative humidity
3 High intensity storms
4 Likely to leach out and/or down into lower layers during storm events
5 Soaked California Bearing Ratio (CBR) and abrasion resistance must be checked / increased with increasing number of trucks to ensure all-weather passability
6 Materials have little or no effective binder content and are prone to washboarding and raveling. Treatments may leach down into road structure
7 May become slippery when wet
8 High fines content may require higher application rates to be effective
9 Requires a minimum humidity level to perform effectively
10 May leach down into layer, but dry back of the material plus a light water spray / rejuvenation will return it to surface
11 Generally not suitable as a spray-on application. A "skin" can form on the surface which is damaged by traffic

Treatment Selection Tools

- Manual using forms in guide
- Spreadsheet (FHWA version)
- Web-based (UCPRC version)
  - www.ucprc.ucdavis.edu/ccpic

Home Page

Unpaved Road Chemical Treatment Selection Tool

Home | Instructions | Treatment Selection | Results Interpretation | About

Welcome to the UCPRC's Unpaved Road Chemical Selection Tool Site

Language & Units
English Spanish
US SI

There are millions of kilometers/miles of unpaved roads around the world managed by numerous authorities, land owners, and public and private organizations. Common to all of these roads are unacceptable levels of dust, poor riding quality and/or impassability in wet weather, and expensive maintenance and gravel replacement activities. Over the last 100+ years, a range of different chemical treatments have been developed to overcome these issues. Most of these are proprietary which can complicate selection of an appropriate treatment for a specific set of conditions. There is also no single product that will solve all problems under all conditions.

Loss of fines (as dust) on an untreated road

A procedure has therefore been developed to guide practitioners in the selection of an appropriate treatment. This procedure, based on the 1999 US Forest Service Guide (*Dust Palliative Selection and Application Guide*), and updated with new research and experience, factors traffic, climate, material properties, and road geometry into the most appropriate treatment selections for a given set of input values. The procedure is based on the philosophy of using chemical treatments to keep good roads in good condition, rather than attempting to use chemical treatments to "fix" bad roads. This unpaved road chemical treatment selection tool and information related to it is fully described in the UCPRC guideline entitled "Unpaved Road Dust Control and Stabilization Treatment Selection Guide." This web-based chemical treatment selection tool can be considered as a companion to the guideline.

The photo on the left shows loss of fines on an untreated road while the photo on the right shows the results of applying a fines preservation treatment.

Stable fines preservation on a treated road

Disclaimer

This unpaved road chemical treatment selection procedure has been developed to guide selection of an appropriate treatment. It is based on the experience of practitioners and documented field experiment results. It is a guide only and does not replace engineering practice and judgment. Before initiating a treatment program, users should check actual performance for their particular materials and conditions with appropriate laboratory performance tests and/or short field experiments and/or seek guidance from other experienced practitioners and treatment suppliers. The University of California Davis does not endorse the use of any specific product for dust control and stabilization of unpaved roads.

☐ **Accept**

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Treatment Selection

Unpaved Road Chemical Treatment Selection Tool

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Road ID | **Details** *

Material Test Results

%Passing 25 *		%Passing 0.425 *	
%Passing 4.75 *		%Passing 0.075 *	
%Passing 2.36 *		PI (or BLSx2) *	

Objective

- (•) Short-term dust control (spray-on)
- ( ) Long-term fines preservation (spray-on)
- ( ) Long-term fines preservation (mix-in)
- ( ) Long-term stabilization (mix-in)

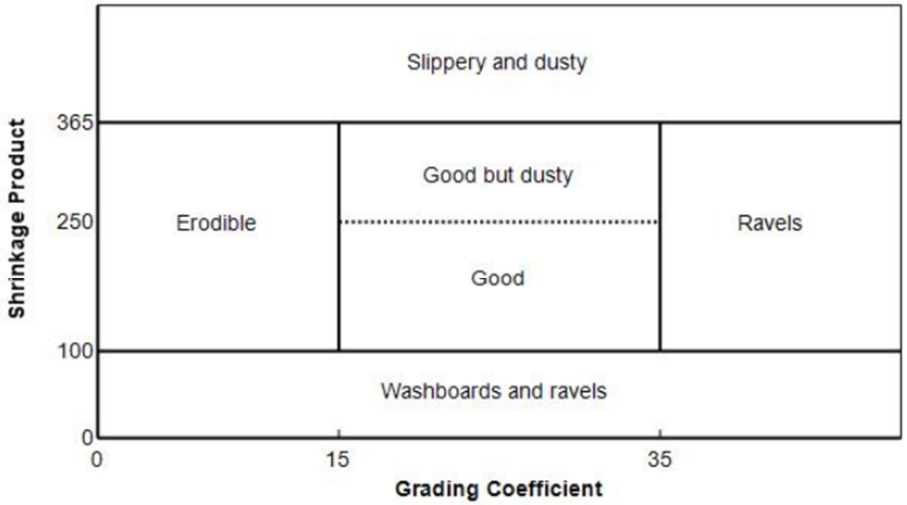
Roadway Parameters

Traffic (AADT) Select * | Climate Select *

- [ ] More Than 10% Trucks
- [ ] Steep Grades
- [ ] Sharp Curves

Compute Ratings | Environmental & Other Influences

Predicted Material Performance for Untreated Road



Treatment Ratings

Treatment	TR	CL	PI	FC	HV	SG	SC	Rating
Water	0	0	0	0	0	0	0	**0**
Water + Surfactant	0	0	0	0	0	0	0	**0**
Calcium Chloride	0	0	0	0	0	0	0	**0**
Magnesium Choride	0	0	0	0	0	0	0	**0**
Sodium Chloride Brine	0	0	0	0	0	0	0	**0**
Glycerin Based	0	0	0	0	0	0	0	**0**
Lignosulfonate	0	0	0	0	0	0	0	**0**
Molasses/Sugar	0	0	0	0	0	0	0	**0**
Plant Oil	0	0	0	0	0	0	0	**0**
Tall Oil	0	0	0	0	0	0	0	**0**
Asphalt Emulsion	0	0	0	0	0	0	0	**0**
Base Oil	0	0	0	0	0	0	0	**0**
Petroleum Resin	0	0	0	0	0	0	0	**0**
Synthetic Fluid	0	0	0	0	0	0	0	**0**
Synthetic Fluid + Binder	0	0	0	0	0	0	0	**0**
Synthetic Polymer	0	0	0	0	0	0	0	**0**
Concentrated Liquid Stabilizer	0	0	0	0	0	0	0	**0**
Bentonite	0	0	0	0	0	0	0	**0**

TR: Traffic; **CL:** Climate; **PI:** Plasticity; **FC:** Fines Content; **HV:** More Than 10% Trucks
SG: Steep Grades; **SC:** Sharp Curves; **Rating:** Treatment Performance Ratings

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Data Input

Unpaved Road Chemical Treatment Selection Tool

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Road ID CR18 **Details** km 1 to km 1

Material Test Results

%Passing 25	100	%Passing 0.425	25
%Passing 4.75	45	%Passing 0.075	15
%Passing 2.36	35	PI (or BLSx2)	10

Objective

- ○ Short-term dust control (spray-on)
- ◉ Long-term fines preservation (spray-on)
- ○ Long-term fines preservation (mix-in)
- ○ Long-term stabilization (mix-in)

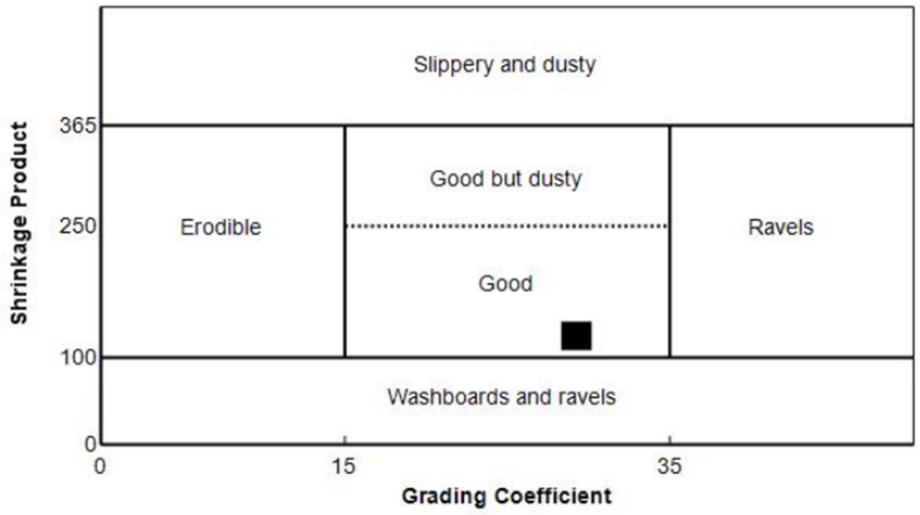
Roadway Parameters

Traffic (AADT): < 100 ▼ Climate: Damp ▼

☐ More Than 10% Trucks ☐ Steep Grades ☐ Sharp Curves

Compute Ratings | Environmental & Other Influences

Predicted Material Performance for Untreated Road



Treatment Ratings

Treatment	TR	CL	PI	FC	HV	SG	SC	Rating
Calcium Chloride	1	1	1	1	0	0	0	1.0
Magnesium Choride	1	1	1	1	0	0	0	1.0
Glycerin Based	1	1	1	1	0	0	0	1.0
Lignosulfonate	1	1	1	1	0	0	0	1.0
Molasses/Sugar	1	1	1	1	0	0	0	1.0
Plant Oil	1	1	1	1	0	0	0	1.0
Tall Oil	1	1	1	1	0	0	0	1.0
Base Oil	1	1	1	1	0	0	0	1.0
Petroleum Resin	1	1	1	1	0	0	0	1.0
Synthetic Fluid	1	1	1	1	0	0	0	1.0
Synthetic Fluid + Binder	1	1	1	1	0	0	0	1.0
Sodium Chloride Brine	1	2	1	1	0	0	0	2.0
Asphalt Emulsion	1	1	2	2	0	0	0	2.1
Synthetic Polymer	2	2	2	2	0	0	0	2.4
Water	3	3	3	3	0	0	0	NA
Water + Surfactant	3	3	3	3	0	0	0	NA
Concentrated Liquid Stabilizer	3	3	3	3	0	0	0	NA
Bentonite	3	3	3	3	0	0	0	NA

TR: Traffic; **CL:** Climate; **PI:** Plasticity; **FC:** Fines Content; **HV:** More Than 10% Trucks
SG: Steep Grades; **SC:** Sharp Curves; **Rating:** Treatment Performance Ratings

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Change in Material Properties

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Material Test Results

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%Passing 2.36	35	PI (or BLSx2)	0

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- ○ Long-term stabilization (mix-in)

Roadway Parameters

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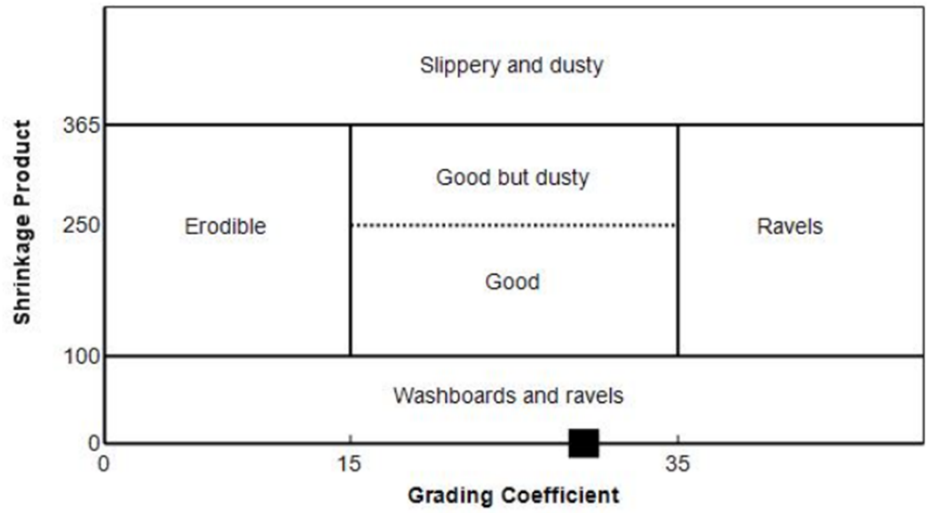

Treatment Ratings

Treatment	TR	CL	PI	FC	HV	SG	SC	Rating
Asphalt Emulsion	1	1	2	1	0	0	0	2.0
Calcium Chloride	1	1	2	2	0	0	0	2.1
Magnesium Choride	1	1	2	2	0	0	0	2.1
Glycerin Based	1	1	2	2	0	0	0	2.1
Lignosulfonate	1	1	2	2	0	0	0	2.1
Tall Oil	1	1	2	2	0	0	0	2.1
Base Oil	1	1	2	2	0	0	0	2.1
Petroleum Resin	1	1	2	2	0	0	0	2.1
Synthetic Fluid	1	1	2	2	0	0	0	2.1
Synthetic Fluid + Binder	1	1	2	2	0	0	0	2.1
Synthetic Polymer	2	2	2	2	0	0	0	2.4
Plant Oil	1	1	3	2	0	0	0	3.0
Sodium Chloride Brine	1	2	3	2	0	0	0	3.0
Molasses/Sugar	1	1	3	3	0	0	0	3.1
Water	3	3	3	3	0	0	0	NA
Water + Surfactant	3	3	3	3	0	0	0	NA
Concentrated Liquid Stabilizer	3	3	3	3	0	0	0	NA
Bentonite	3	3	3	3	0	0	0	NA

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Change of Objective

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- Long-term stabilization (mix-in)

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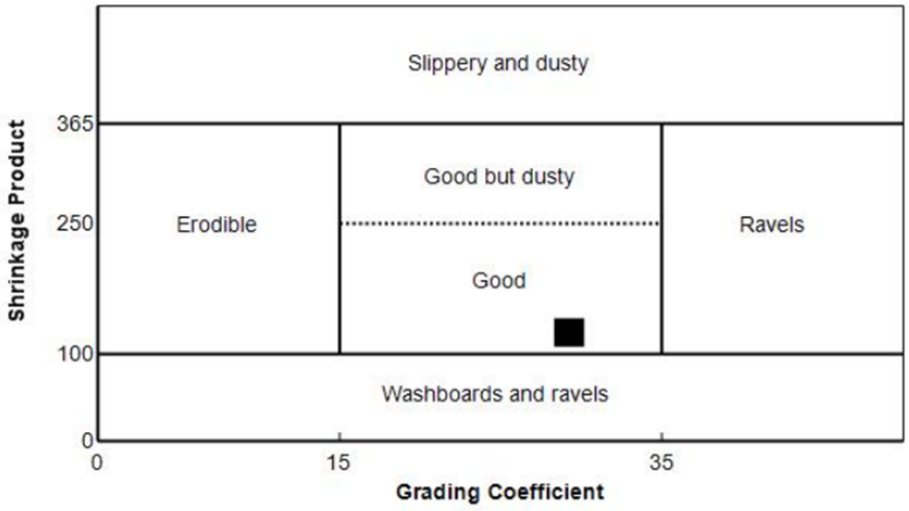

Treatment Ratings

Treatment	TR	CL	PI	FC	HV	SG	SC	Rating
Petroleum Resin	1	1	1	1	0	0	0	1.0
Synthetic Fluid + Binder	1	1	1	1	0	0	0	1.0
Synthetic Polymer	1	1	1	1	0	0	0	1.0
Asphalt Emulsion	1	1	2	2	0	0	0	2.1
Concentrated Liquid Stabilizer	1	1	2	2	0	0	0	2.1
Calcium Chloride	2	1	2	2	0	0	0	2.3
Magnesium Choride	2	1	2	2	0	0	0	2.3
Lignosulfonate	2	1	2	2	0	0	0	2.3
Tall Oil	2	1	2	2	0	0	0	2.3
Sodium Chloride Brine	2	2	2	2	0	0	0	2.4
Bentonite	1	1	3	3	0	0	0	3.1
Water	3	3	3	3	0	0	0	NA
Water + Surfactant	3	3	3	3	0	0	0	NA
Glycerin Based	3	3	3	3	0	0	0	NA
Molasses/Sugar	3	3	3	3	0	0	0	NA
Plant Oil	3	3	3	3	0	0	0	NA
Base Oil	3	3	3	3	0	0	0	NA
Synthetic Fluid	3	3	3	3	0	0	0	NA

TR: Traffic; **CL:** Climate; **PI:** Plasticity; **FC:** Fines Content; **HV:** More Than 10% Trucks
SG: Steep Grades; **SC:** Sharp Curves; **Rating:** Treatment Performance Ratings

Suppliers | Print

Other Considerations

Additive Sub-Category	Leaching Stability	Aquatic Impacts	Plant Impacts	Mammal/Human Impacts	Soil Chemistry	Grader Maintainability
Water	Stable	No impact[1]	No impact	No impact	No effect	Yes
Water/surfactant	Stable	No impact[1]	No impact	No impact	No effect	Yes
Calcium chloride	Leaches down[2,3]	Potential impact[5]	Potential impact[7]	Potential impact[8]	Check[9]	Yes[12]
Magnesium chloride	Leaches down[2,3]	Potential impact[5]	Potential impact[7]	Potential impact[8]	Check[9]	Yes[12]
Sodium chloride brine	Leaches out[2]	Potential impact[5]	Potential impact[7]	Potential impact[8]	Check[9]	Yes[12]
Glycerin based	Leaches out[2]	Potential impact[6]	No impact	Potential impact[8]	No effect	Yes[12]
Lignosulfonate	Leaches out[2]	Potential impact[6]	No impact	No impact	No effect	Yes[12]
Molasses/sugar	Leaches out[2]	Potential impact[6]	No impact	Potential impact[8]	No effect	Yes[12]
Plant oil	Leaches out[2]	Potential impact[6]	No impact	No impact	No effect	Yes[13]
Tall oil	Stable	No impact	No impact	No impact	No effect	Yes[12]
Asphalt emulsion	Stable	No impact	No impact	No impact	Check[10]	No[14]
Base oil	Leaches down[4]	No impact	No impact	No impact	No effect	Yes
Petroleum resin	Stable	No impact	No impact	No impact	No effect	Yes[13]
Synthetic fluid	Leaches down[4]	No impact	No impact	No impact	No effect	Yes
Synthetic fluid + binder	Stable	No impact	No impact	No impact	No effect	Yes[15]
Synthetic polymer	Stable	No impact	No impact	No impact	No effect	No[14]
Conc. liquid stabilizers	Stable	No impact	No impact	No impact	Check[11]	Yes
Bentonite	Stable	No impact	No impact	No impact	No effect	Yes[12]

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Outline

- Introduction
- Unpaved roads
- Additive categories
- Additive selection
- **Specifications**
- Summary

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Specifications

- Literature review and discussions
  - ASTM Specs
  - FHWA Standard Specs
  - County specs
- Qualified product lists
- Clear need for generic specifications to cover all product sub-categories
  - Procurement, environmental, and application

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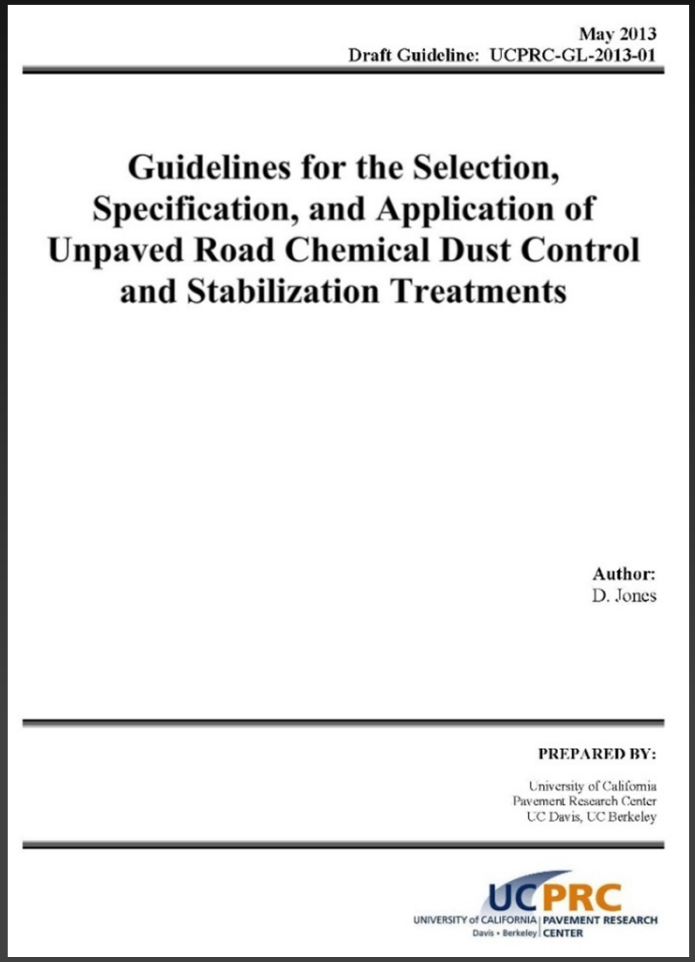
Procurement

- Based on any agency being able to specify a category of product(s) based on selection results
- Certificate of compliance
  - Product name and category
  - Verifications
    - Category requirements
    - Safety data sheet
    - Environmental requirements
- Category specifications
  - ASTM format, based on current calcium chloride specification
  - ASTM tests
- Example language provided in guide



May 2013
Draft Guideline: UCPRC-GL-2013-01

Guidelines for the Selection, Specification, and Application of Unpaved Road Chemical Dust Control and Stabilization Treatments

Author:
D. Jones

PREPARED BY:

University of California
Pavement Research Center
UC Davis, UC Berkeley

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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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Treatment Application

- Example specification language for:
  - Chemical treatment application plan
  - Contractor compliance
  - Equipment
  - Weather conditions
  - Application
    - Surface preparation
    - Spray-on
    - Mix-in
    - Curing
    - Records
  - Warranties

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Application

- Performance will always be linked to application
- Always prepare the road appropriately
- Use mix-in treatments where possible, multiple spray-on treatments if not
- Incorporate during regravelling
  - Chemical substitutes compaction water
- Shape and compact
- Ensure adequate drainage
  - Crossfall and side (off and away)

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Why Compact?

- ± 2,000 tons to place 75mm of gravel on a 1.5km x 7m road
- 25mm lost within 3 months if not compacted

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Summary

- Huge range of chemical treatments
- There are no "wonder" products
- Select treatment based on
  - Problem/objective
  - Traffic, climate, and materials (test!)
  - Cost-benefit
  - Vendor credibility
- Understand likely performance
- Apply and maintain appropriately
- Use treatments as part of a road management strategy to keep a good road good

Time for a Break?

djjones@ucdavis.edu www.ucprc.ucdavis.edu/ccpic

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Save the Date

- 12th Transportation Research Board International Low Volume Roads Conference
- Kalispell, Montana, September 15 -19, 2019