North Dakota Missile Road Gravel Stabilization with Calcium Chloride

Stephen Monlux, LVR Consultants LLC, Missoula MT
stevemonlux@gmail.com 406-544-1919

Note that the information provided in this presentation was prepared for tech transfer only and does not supersede any contract requirements.

Also, the interpretation of plans and specifications in this document come from a person with no contract authority.

Presentation Objectives

- Determine if the MT missile road gravel stabilization process will work well with North Dakota specifications and gravel
- Determine if chloride stabilization is cost effective
- Transfer knowledge developed from 10 years of experience from the MTDAR program
- Ensure that all become aware of problems that can develop during construction
- Challenge local Contractors and County road crews to determine better ways to do chloride stabilization
- Stimulate group discussion and obtain feedback
- Develop a plan that will complete the contract in a timely and cost effective manner.

2

Presentation Resources

- FHWA 2017 Chloride Stabilization Report (MT Missile Roads)
- Braun Intertec 3-25-2020 Report on G-11 and G-08N
- NDLTAP 2017-19 "Clay is the Glue"
- IDLTAP 2002-2019 "Gravel Road Design and Maintenance"
- MillRazor Manual 2018 "User Guide for Stabilized Gravel"
- One Page Guides for Adding Clay
  - 2017 - Adding Clay with Belly Dump Trucks
  - 2019 - Adding Clay with Water trucks
- Spokane Co 2019
  - "Gravel Road Improvement Plan" and
  - "Guidelines for Gravel Road Testing Projects"
- USAF Workshops 2008 "Malmstrom Missile Road QA/QC for Chloride Stabilization"

3

Presentation Modules/Outline

- Introduction
- 1 Expected Gravel Performance
- 2 Performance Measurements
- 3 Construction Equipment
- 4 Construction Procedure
- 5 Quality Control and Quality Assurance
- 6 Maintenance of Chloride Stabilized Gravel
- 7 Conclusions

4

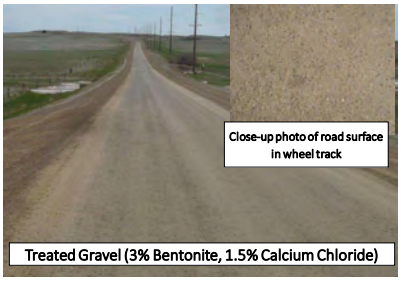
Introduction

- Chloride Stabilization Benefits:
  - Less rock loss per year: ½" to 1/8" (MT Missile Road study after 6 years)
  - Less blading costs by 65%
  - Other Benefits: Saves gravel resources, increases road user safety, less vehicle maintenance, less dust, greater fuel economy, improved public relations
- Problems:
  - Higher initial cost, better gravel, clay
  - Process requires attention to details
- Purpose of Presentation: Explain details

West Tensleep Road, Big Horn NF 2006

5

Chloride Treated Gravel Surfacing (1 yr. old)



6

Module 1: Expected Performance

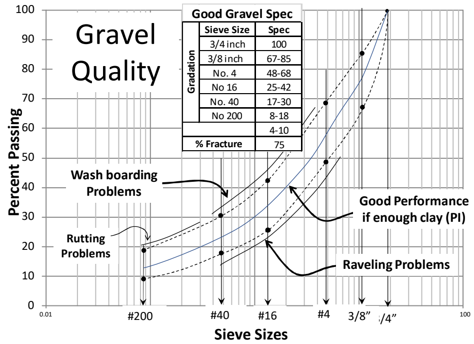
- Will likely be less effective than MTDAR because gravel gradation, PI and construction practices.
- List of reasons why lower performance
  - Sandy gradations with lower % Fracture wash board and ravel
  - Low clay contents (plasticity index) allow chloride leaching
  - Construction process more complicated, treatment depth control less precise

* Consequences of lower performance

Greater performance problems (dust, washboards, raveling)

More frequent blading

More frequent gravel replacement

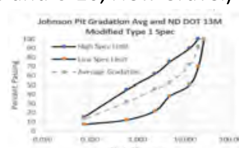


Good Gravel Spec

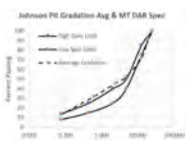
	Sieve Size	Spec
Gradation	3/4 inch	100
	3/8 inch	67-85
	No. 4	48-68
	No 16	25-42
	No. 40	17-30
	No 200	8-18
		4-10
% Fracture		75

Gradation Summary Graphs (Site D-3 and C-10, New Gravel)

Sieve Size			Spec 816.02 Class 13M Mod. Type 1		Gravel Source: Johnson Pit – Test Number						Average
Std	mm	$mm^{0.45}$	High	Low	1	2	3	4	5	6	
1"	25.000	4.257	100	100	100	100	100	100	100	100	100
3/4"	19.000	3.762	100	70	92	93	88	93	90	92	91
1/2"	12.500	3.116	90	50	74	75	67	72	69	73	72
#4	4.750	2.016	75	38	55	56	48	51	51	53	52
#8	2.360	1.472	62	22	48	49	42	44	44	47	46
#30	0.600	0.795	45	12	33	34	29	31	31	33	32
#200	0.075	0.312	15	7	14.2	13.4	11.8	12.3	12.7	13.7	13.0
Plasticity			9	4	8	7	9	8	9	7	8.0



Sieve Size		2019 MT DAR Spec Target Limits (Table 703-3A)	
Std	mm	High	Low
1"	25.000	100	100
1/2"	12.500	85	75
#4	4.750	50	40
#10	2.000	40	25
#40	0.425	25	15
#200	0.075	14	8
Plasticity		10	4



P200 + PI = 21

Important "Take Aways" for New Gravel

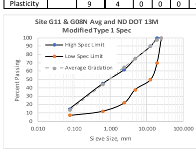
- Somewhat more dusting, wash boarding and blading than most Montana missile roads
  - P200 + PI = 21 is lower → low "binder" more raveling, dusting
  - Gradation has more sand, higher voids → more chloride leaching, more dusting, shorter gravel life
- Adding 1.5% bentonite during maintenance blading will:
  - Reduce blading
  - Reduce dusting
  - Increase chloride life
  - Increase gravel life
- Suggested method for adding bentonite → water truck with bentonite slurry
- The sample used for the "modified" density test should have a similar gradation and PI to the average shown on the previous slide

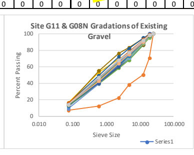
	Average
1"	100
3/4"	91
1/2"	72
#4	52
#8	46
#30	32
#200	13.0
Pla	8.0

Gradation Summary Graphs (Sites G-11, G-08N Old Gravel)

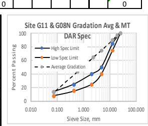
Sieve Size			Spec 816.02 Class 13M Mod. Type 1		Existing Gravel on Sites G11 & G08N (Sample MP start from North) – MP 2		MP 3		MP 4		MP 5		MP 6		MP 7		MP 8		MP 9		MP 10		MP 11		MP ?					Average
Std	mm	$mm^{0.45}$	High	Low	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	?	2	3	4	5	
1"	25.000	4.257	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	[illegible]	[illegible]	[illegible]	100	100	100	100	100	100	100
3/4"	19.000	3.762	100	70	99	97	99	96	97	95	98	99	99	99	99	98	95	97	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	98	97	97	98	98	98	98
1/2"	12.500	3.116	90	50	92	88	93	86	87	87	88	94	95	90	90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	90	90	91	91	90	92	90
#4	4.750	2.016	75	38	76	76	75	68	70	74	75	83	82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	76	73	76	76	75	77	75
#8	2.360	1.472	62	22	64	69	62	58	60	63	66	76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	61	68	64	67	63	65	67	64	68	65
#30	0.600	0.795	45	12	43	53	45	39	40	42	45	55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	44	40	40	40	46	45	45	42	43	45	42	47	44
#200	0.075	0.312	15	7	11.0	16.0	15.0	12.0	12.9	12.6	12.2	15.0	[illegible]	[illegible]	[illegible]	13.2	14.8	15.5	13.8	14.0	14.5	15.7	13.8	12.8	12.0	13.0	14.0	14.0	14.0	13.6
Plasticity			9	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0

P200 + PI = 14





Sieve Size		2019 MT DAR Spec Target Limits (Table 703-3A)	
Std	mm	High	Low
1"	25.000	100	100
1/2"	12.500	85	75
#4	4.750	50	40
#10	2.000	40	25
#40	0.425	25	15
#200	0.075	14	8
Plasticity		10	4



Important "Take Aways" for Old Gravel

- Significantly more dusting, wash boarding and blading than all the Montana missile roads
  - P200 + PI = 14 is much lower → low "binder" more raveling, dusting
  - Gradation has much more sand, higher voids → rapid chloride leaching, more dusting, shorter gravel life
  - If dust abatement is needed only apply surface applications
- Adding 3% bentonite during maintenance blading will:
  - Reduce blading and dusting to some extent
  - Increase chloride and gravel life to some extent
  - May cause rutting and sloppy road surfaces in the spring – CBR/chloride leaching testing is suggested confirm 3% bentonite addition
- Suggested method for adding bentonite → Belly dump with gravel containing high concentrations of dry bentonite
- The sample used for the "modified" density test should have a similar gradation and PI to the average shown on the previous slide

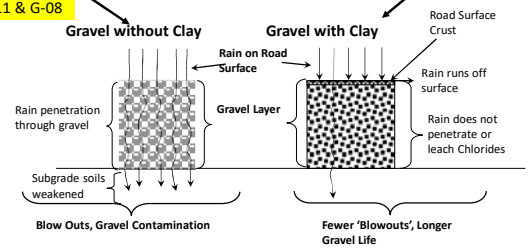
	Average
1"	100
3/4"	98
1/2"	90
#4	75
#8	65
#30	44
#200	13.6
Pla	0

Clay Binder

- Fills voids in gravel, forms road crust, sheds rain, retains chloride
- Chloride keeps clay from dusting

Similar to In-Place Gravel at Site G-11 & G-08

Similar to New Gravel for Sites D-3 & C-10



13

Consultant Investigation Notes for Site G11, G-08N

- Moisture Density Testing
  - Must do modified T180 Moisture Density (MD) - per Section A of SP 892.
  - Optimum moisture by standard MD is too high, maximum density too low
- Optimum chloride content by MD test is generally unreliable
  - See recent TRB paper on CBR/Chloride retention testing which evaluates suitability of aggregate for chloride treatment.
  - Target chloride content of 1.85% is good standard, **MORE IS NOT BETTER** because higher chloride contents can retain water above optimum moisture, delay project completion, cause rutting and serious Public Relations issues.
- Sandy gradations, with low % fracture and clay content will cause the following problems
  - Wash boarding
  - Short chloride treatment life due to leaching
  - More frequent blading
  - Shorter gravel life
- No mention of crown measurements in report
  - Low crowns pothole badly

Suggest crown and additional thickness measurement at road shoulder ASAP

14

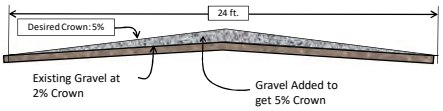
Potholes and Crown

15

Tons Gravel Needed per Mile to Build Crown

Difference Between Existing and Desired Crown, %	Tons of Gravel per Mile to Increase Crown — Gravel Width, ft													
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	228	257	289	322	356	393	431	471	513	557	602	650	699	749	802
2	456	515	577	643	713	786	862	943	1026	1114	1205	1299	1397	1499	1604
3	684	772	866	965	1069	1179	1294	1414	1540	1671	1807	1949	2096	2248	2406
4	912	1030	1155	1287	1426	1572	1725	1885	2053	2228	2409	2598	2794	2997	3208
5	1140	1287	1443	1608	1782	1965	2156	2357	2566	2784	3012	3248	3493	3747	4010

1540 Tons/Mile



16

Module 2: Simple Performance Measurements

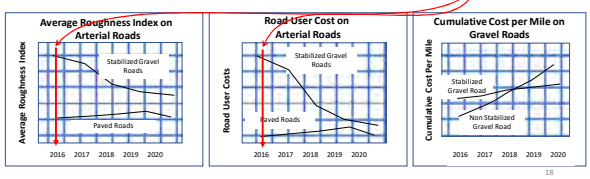
- Develop a plan for documenting "Before" and "After" performance
- **Tools to measure and document conditions**
  - **Photos at specific locations or video log**
  - **Defect ratings by "Gravel PASER" or similar**
  - **Dust measurement – DustTrak DRX Aerosol Monitor (Model 8533, TSI Incorporated) or similar**
  - **Road roughness measurement - Road Bump App for Android**
  - **Road User Costs from road roughness – http://worldbank.org/roadsoftwaretools/**
  - **Life Cycle Cost from UGPI Local Road Surfacing Selection Tool**
- **Try to make it simple, yet meaningful to "management" and road users**

17

Cost & Benefit Measurements

- Methods for measuring benefits
  - Defect ratings by "Gravel PASER"
  - Dust meters
  - Road Roughness - Bump App for Android
  - Before and after photos or video log
- Graphs to illustrate benefits of gravel road improvements

Take measurements prior to starting stabilization work



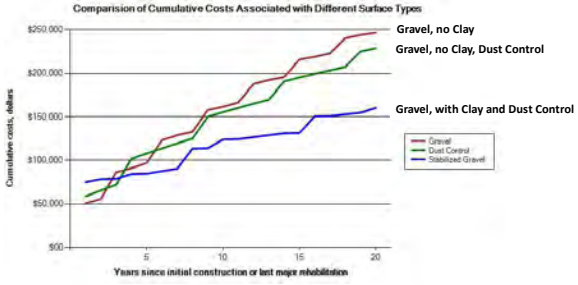
18

NDSU Surfacing Selection Tool

https://www.ugpti.org/resources/surface-selection/

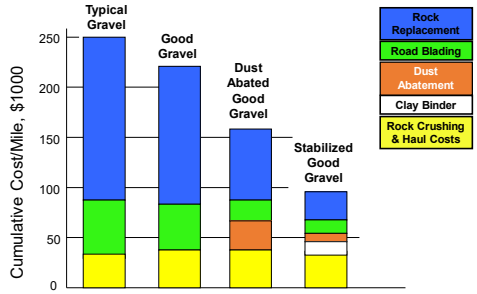
19

Life Cycle Cost Comparisons



20

Long Term Cumulative Cost Comparisons



21

Reduction in Gravel Replacement

Year of Crushing	Tons Crushed	Tons Used for New Roads	Tons Left in Stockpile Inventory	Tons Used for Gravel Replacement	Years Between Crushing Contracts	Annual Tons Used for Gravel Replacement
2000	50,000	10,000	10,000	30,000		
					5	6,000
2005	50,000	12,000	10,000	28,000		
					6	4,667
2011	50,000	14,000	10,000	26,000		
					7	3,714
2018	50,000	16,000	10,000	24,000		

22

Module 3: Construction Equipment

- Water truck
- Blades
- Chloride spreader
- Mixer/reclaimer
- Rollers
- Pugmill and feeder bins

23

Water Trucks

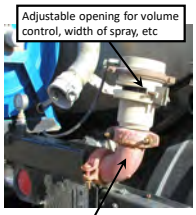
- Uniform spray pattern
- No intersecting patterns
- Efficient fill up, close water points, more than one truck
- Front spray head

24

Adjust One Head for Heavy "Soaking" and another Light Rain Application

25

Suggested Spray Heads



Courtesy: Bertolini Valves, Inc 650-598-0225

Use 2 couplings for **left** and **right** spray adjustment as well as **up** and **down** with grooved elbow shown above

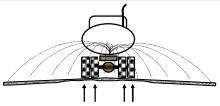
26

Poor Watering Equipment

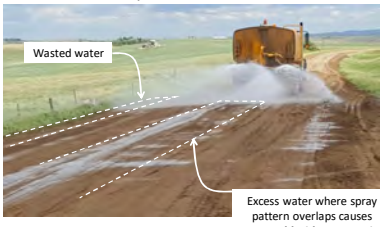
Lethbridge Co AB

27

Uniform Water Application



Non-uniform water application causes **uneven chloride penetration**



Less water and chloride penetration in water truck wheel tracks
Consider front spray heads

Delamination caused by watering windrows

28

Water Trucks - Pump and Vacuum Filled

Ensure that water trucks are properly equipped:

1. Have long enough hoses
2. Can draft efficiently from all water point locations
3. Use portable pumps with hoses if necessary
4. If hiring commercial trucks, use the "Water Truck Specification"

29

Water Truck with Front Spray Head

- More even penetration on loose gravel surface (not watering in water truck wheel tracks)
- Driver can compensate for cross wind
- Driver can water one lane without watering the other
- Driver can avoid watering windrows
- Driver can better evaluate truck speed to fully saturate yet avoid shoulder runoff

30

Blades

- Slope meter
- Carbide cutting edges
- Moldboard extensions

31

Slope Meter Suggested for all Blades

The No 2 Slope Meter measures slope in percent

wwwslopemeter.com
763-572-0336

Note: Follow manufacturers installation instructions so these devices work accurately.

32

Carbide "Pick" Blade Attachment

Richland Co MT

Advantages of "Pick" Attachments:
- More efficient cutting hard surfaces
- Better crowns – no wear in middle

Concerns about segregation can be solved with higher moisture content

33

Carbide and Hardened Cutting Edges

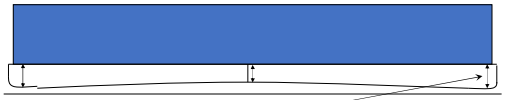
- Long life
- Always true, no wear
- Higher fuel consumption

Rocky View Co AB

34

Standard Cutting Edge Wear

Cutting Edge Wear



Measure cutting edge at 3 locations
Differential Wear = max difference in measurements

35

Truing Worn Cutting Edges

True edges with torch or on flat chip sealed pavement
(Be aware of wild fire problems)

Sheridan Co, WY

36

Moldboard Extension (Richland Co, MT)

37

Dry Calcium Chloride Spreaders

- Objectives: Uniform and accurate spread
- Types of dry product spreaders
  - Fertilizer spinner spreaders (RM Equipment)
  - Soil Stabilization Spreaders (Stoltz, etc.)
  - Slurry Spreaders (venturi and tank mixers, water trucks)
- Unique Characteristics of Calcium Chloride
  - Corrosive
  - Pellets/flakes can stick together causing spreading problems
  - Attracts moisture – must be protected from rain
  - Chloride dust sticks to everything (the start of the corrosion process)
  - Daily equipment washdown required

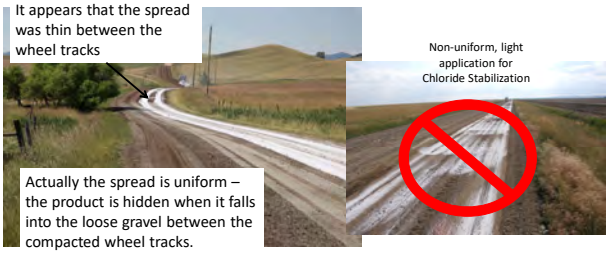
38

Fertilizer Spinner Type Spreader

Johnson Co, WY

39

Dry Product Spread Uniformity



40

Chloride Application Rate

- Application Rate Checks
  - Visual evaluation
  - Spread test
  - Yield test

41

Dry Product Spreaders – Stoltz, etc.

42

43

Liquify Dry Products into Water Slurry

- Pre-rip and or Pad Foot Roll surface prior to application
- Be aware of heat generation when making slurry
- Liquid must not exceed optimum moisture when mixed with road materials
- Calcium Chloride slurry above 1% will exceed optimum moisture of gravel.

Mag chloride brine does not work because of this

44

Reclaimer/Mixer

- Accurate and uniform depth control
- Accurate and uniform water application at low GPM

45

Cat RM 300 Reclaimer

All electronics are sensitive to chloride corrosion from dust that clings to everything – clean daily

46

Uniform Water Application and Mixing Depth

Mixing Depth Accuracy
Check rim height/tire pressure

Clean up mixing chamber and water nozzles

Richland Co MT

47

Low Water Application Rates

- Typical nozzle size for Cat reclaimer →
- GPM for 1% additional moisture at 2 MPH (176 ft/min →10560ft/60min)
- GPM = (1% x 8' x 4/12'x 176ft/min x 135lb/CF)/(8.34lb/gal) = 76 GPM or about **5 gpm per nozzle**.
- The standard H3/4U-50400 minimum flow is 14 GPM at 5 psi.
- Options to consider:
  - Add water during gravel laydown and blade processing, don't use reclaimer to add water
  - Shut off half of the nozzles
  - Purchase nozzles with smaller orifice
- Do nothing – uneven water spray will require more blade processing, potential rework issues to meet compaction specs.

These Spray Systems Inc. nozzles have ½" orifice that resists clogging – they fit ¾" Pipe

http://www.ispray.com/ecatalog/part-search
Type in part number "H3/4U-50400". Cost is $21 each for more than quantity of 12.

48

Rollers (SP 892 Refers to Sec 151 in 2014 Std Specs)

- Spec Review
- 15 Ton or larger rubber tire rollers (Per 2017 MT Missile Road Report)
- Ballast
- Tire pressure
- Advantages of Rubber tire rollers
- Problems with steel rollers
- Best use of steel vibratory rollers

49

Spec Review

- Pneumatic Tired Rollers (Section 151.01A)
  - Towed:
    - At least 7 wheels, info from mfg. on contact pressure
    - Ballasted to at least 225 lbs. per inch tire width
    - Provide empty and ballasted weights
  - Self Propelled:
    - No wobble wheel-rollers
    - Contact pressure between 40 and 90 psi. Contact pressure = wheel load on ground/contact area in square inches

13 wheel towed rubber – Lethbridge Co AB

Light Self Propelled

12 to 15 ton Self Propelled

50

Roller Spec Review

- Steel Vibratory Rollers (Section 151.01B)
  - Provide empty and ballasted weight
  - 4 mph max in static mode, 1 to 4.5 mph in vibratory mode
  - See frequency/amplitude-mph table in vibratory mode
- 15 Ton or larger rubber tire rollers (Per 2017 MT Missile Road Report)

11 Ton – Lethbridge Co AB

15 to 30 Ton – Richland Co MT

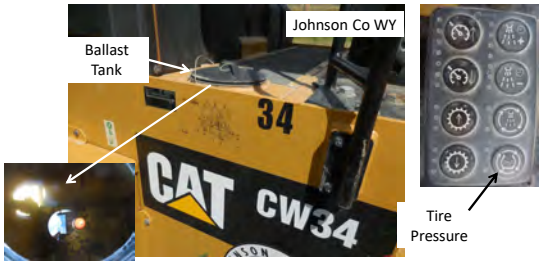
51

Advantages of Rubber Tire Rollers

- Finds and compacts soft areas – does not "bridge over"
- Kneads and confines while compacting
- Less pickup of gravels with clay
- Can change ballast and tire pressure to accommodate different conditions
- Can be effective for "pumping" fines to create a road crust on the gravel surface

52

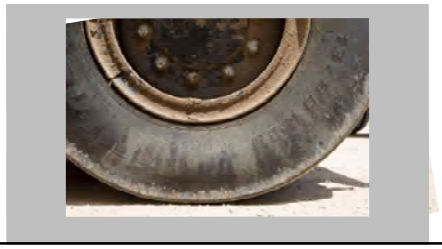
Self Propelled Rubber Roller Ballast ? Tire Pressure



53

Tire Pressure

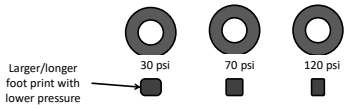
* Reduce tire pressure if rutting is excessive
* Increase tire pressure to increase compaction or reduce the number of passes



54

Fill Ballast Compartment(s) and Check Tire Pressure

- Full Ballast rollers compact gravel with fewer passes.
  - Water: 60 lbs./cubic foot, 8.3 lbs./gallon
  - Sand: 90 lbs./cubic foot, 12 lbs./gallon
  - Wet Sand: 120 lbs./cubic foot, 16 lbs./gallon
- If ruts cannot be rolled out, either
  - Enlarge tire foot print by reducing tire pressure
  - Consider reducing gravel moisture



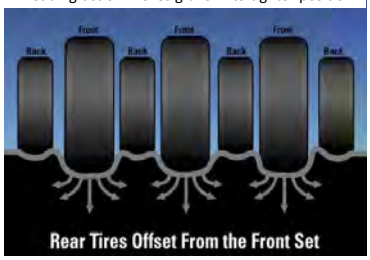
55

Rubber Tire Roller Benefits

56

Rubber Tire Roller Benefits

Kneading action moves gravel into tighter position



57

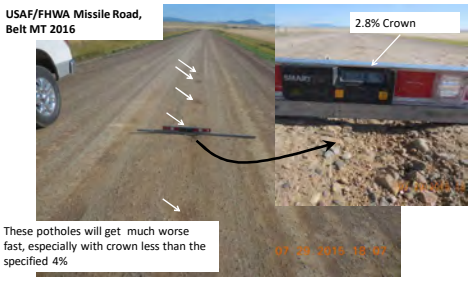
Problems with Steel Rollers

The "divots" caused by material sticking to the drum will form potholes – see next slide.

Re-blade to the depth of the potholes, mix in water as needed to get compaction, and re-compact

58

Potholes Caused by Steel Rollers



59

Best Use of Steel Rollers

- Finish rolling after final blading helps meet ½ inch in 10 feet tolerance (SP 892 Section E.5. ¶ 1)
- Build road surface crust after compaction and finish blading is done
  - Add water if necessary
  - One fast pass with high amplitude and low frequency, pumps fines to surface

60

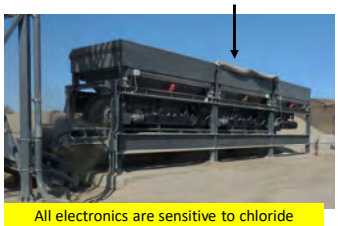
Pugmill and Feeder Bins

- Paddle and chamber wall clearance
- Mixing level/Mix time within chamber
- Water and chloride mixing uniformity
- Daily cleaning of mix chamber, feeder bins and electronic sensors

61

Pugmills and Feeder Bins

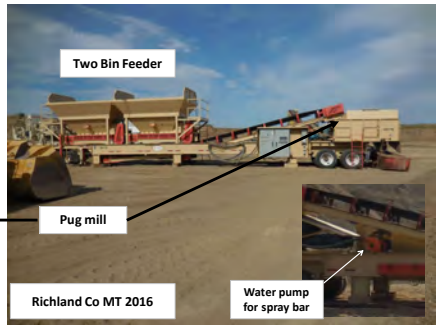
Bin covers for dust and moisture control



All electronics are sensitive to chloride corrosion from dust that clings to everything – clean daily

62

Pugmills and Feeder Bins



63

Equipment and Procedure Changes to Consider

- Front spray head on water truck
- Adjustable flow, width and angle of spray heads on water truck
- Smaller spray nozzles for RM 300
- Carbide cutting edges and moldboard extension for 14M
- Heavy self propelled pneumatic rollers

64

Module 4: Construction Procedure

- Develop a work plan
- Weather considerations
- Reshape existing roadway to 4% crown
- Load, haul and apply new aggregate (Site D-3 and C-10)
- Water, process and shape new gravel
- Blade marks centerline
- Apply calcium chloride
- Reclaimer mix chloride into gravel and compact
- Blade process treated material full depth & width
- Shape to 4.5% crown
- Compact with pneumatic rollers
- Final blading, rolling with vibratory steel roller
- Problems in the Finished Surface
- Conclusions

65

Work Plan – Day One

- Applicator truck loaded - each operator observes
- Mob all equipment, additives, etc. to project
- Set up traffic control
- Stabilize 500 ft. – each operator watches each operation
  - Rebuilding 4.5% crown
  - Additive application
  - reclaimer and water truck operation
  - Initial rolling
  - Finish blading and rolling, final watering
- Stabilize a longer segment but do it as a work team
- Clean out Reclaimer and Applicator truck
- Estimate road length to treat on day two
- Shape 4.5% crown for road on day two

66

Work Plan: Less Than 2 Miles/Day

- Load and haul additives to project
- Set up traffic control
- Blade scores centerline, start additive application, then Reclaimer, rolling, blading, etc.
- Blade operator scores more centerline, then starts 5% crown prep for next day work
- Ground man/Foreman checks all phases of work
  - Traffic control
  - Crown prep
  - Center line mark
  - Additive App/spreading
  - Mixing depth
  - Moisture content
  - Roller speed and pattern
  - Finish blading, crown, surface tolerance
  - Final rolling & compaction
  - Uniform watering
  - Equip Maintenance

67

Work Plan: Less Than 2 Miles/Day

- By 10 am, Foreman decides where to turn around so both lanes are done by end of day
- By 1 pm, Foreman estimate shut down time and length of road to treat the next day
- Shut down Spreader then Reclaimer
- Clean Spreader and Reclaimer, lube and fuel all equipment, fill water truck
- Foreman checklist – end of day
  - Checks weather forecast for next day
  - Briefs crew on next day start times for each phase
  - Asks for questions and input

68

Work Plan Time Line: More Than 2 Miles/Day

- Same as "less than" 2 miles per day except for the following
- Consider need for more blades, water trucks & rollers
- Reduce number of Reclaimer turn arounds to maximize production
- **Watch the weather**
- Plan to use 2 rollers
  - One roller behind Reclaimer to start curing process
  - Second roller rolls behind blade
  - Rollers never stop rolling

69

Personnel and Equipment Needs

- Supervisor/Ground Man – **11 tasks**
- Chloride distributor truck and driver
- Water truck(s), driver(s) and pumps. Trucks must have strong pintle hitch and push bar(s)
- Reclaimer and Operator
- Roller(s) and Operator(s) – 2 needed, more if >2mi/day
- Blade(s) and Operator(s) – 2 needed if >2mi/day
- Traffic control equipment and personnel
- Laborer to assist loading additive and water, daily reclaimer cleanup etc.
- Testing technician for density testing

70

Weather Considerations (SP 892 Section B Paragraph 1)

- Start: Over 40 °F for 48 hours
- Finish: Before Sept 15
- Stop mixing chloride 24 hours before rain.
- Mixture cure period depends on weather conditions
- Wet Weather Precautions
- Precautions for Spring and Fall Operations

71

Wet Weather Precautions

72

Weather

- Doppler Radar on smart phones – go to: radar.weather.gov
- Click on closest radar site

73

Weather and Mix Curing

- Always finish your compaction as soon as possible to reduce rain problems and speed curing
- When curing, the mix gains more strength over time
- During initial curing, the mix can be moved by heavy traffic, often resulting in a lower crown
- Mix curing (equilibrium) takes 3 days to 2 weeks – longer times for cool weather.
- In the Fall, if you get too much moisture in treated gravel :
  - The mixture may rut for months, and
  - Won't freeze up during the winter.

74

Plan for Unexpected Rain

- Stop spreading chloride
- Start mixing shallow and fast to incorporate dry chloride

If you allow chloride to absorb rain water – **you are screwed** -

Water absorbed by chloride must be moisture within the gravel

- Compact mixed gravel with all equipment available
- Lightly blade to remove any ruts that could collect water and compact
- Look at doppler radar to develop work plan
- Reshape and compact as much additional new road as possible, taking advantage of the rains

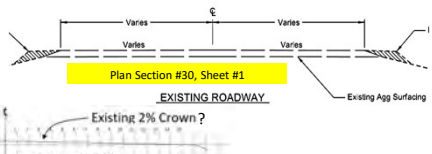
75

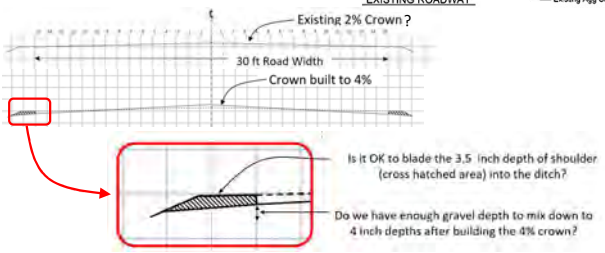
Reshape Existing Roadway (SP 892 Section B ¶ 4)

- Mow and disc shoulder, recover gravel and reshape shoulder
  - Leaving recovered vegetation and gravel on edge of gravel for a day or two makes it easier to remove vegetation and large rocks.
- Fix soft spots in the subgrade by sub-excavation and gravel
  - Observations: subgrade issues usually not as obvious in July and August, and chloride stabilized gravel will fail over soft spots
- Cut out all washboards, potholes, build 4% crown, compact
  - Hopefully there is enough gravel to build a 4% crown – suggest measuring existing crown and gravel depths along shoulder to verify ASAP
- Spread and mix chloride within 5 days
  - Existing gravel is so sandy, shaping the day ahead of adding chloride will likely be necessary. Daily watering will reduce blading.

76

Enough Gravel to Build Crown?



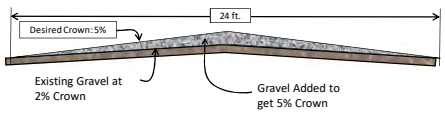


77

Tons Gravel Needed per Mile to Build Crown

Difference Between Existing	Tons of Gravel per Mile to Increase Crown													
	Gravel Width, ft													
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	228	257	289	322	356	393	431	471	513	557	602	650	699	749	802
2	456	515	577	643	713	786	862	943	1026	1114	1205	1299	1397	1499	1604
3	684	772	866	965	1069	1179	1294	1414	1540	1671	1807	1949	2096	2248	2406
4	912	1030	1155	1287	1426	1572	1725	1885	2053	2228	2409	2598	2794	2997	3208
5	1140	1287	1443	1608	1782	1965	2156	2357	2566	2784	3012	3248	3493	3747	4010

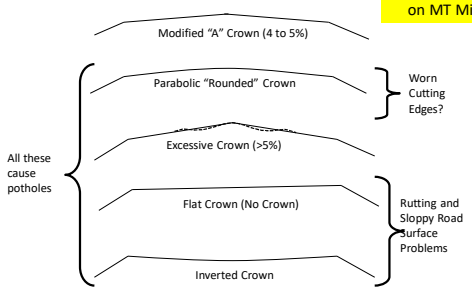
1540 Tons/Mile



78

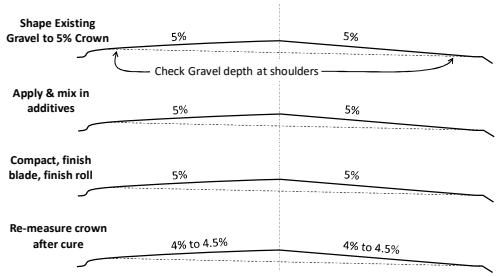
Types of Road Crowns

4% in Contract. 5% used on MT Missile Rds.



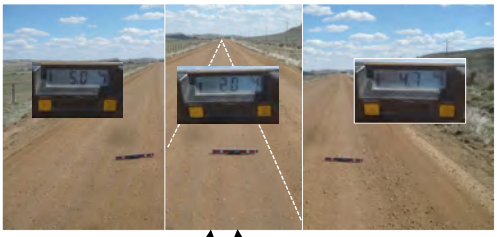
79

Crown Reduction During Chloride Cure Period



80

Crown and the Pot Hole Zone



81

Road Center Potholes:
Less than 4% Crown or Flattened Crown

82

Pot Hole Reduction → Higher Crown

83

Prewetting Road Surface

- Purpose
  - Improves Blading Efficiency
  - Helps get close to best compaction moisture
  - Controls segregation
- Timing
  - Day before blading or early morning

Note that water truck watering **can not** equal rain over a period of days or in the spring after snow melt.

0.1 inch rainfall = 8000 gallons per mile (24' wide road)

84

Second Application where Heavier Cutting Needed

85

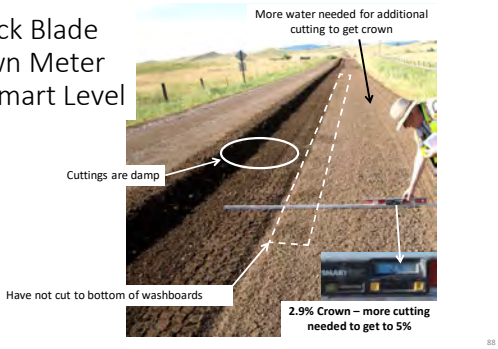
Watering Problems

86

Blading Remove Defects & Build Crown

87

Check Blade Crown Meter with Smart Level



88

Additional Water Helps Cutting and Reduces Segregation

89

Moisture Issues

When windrows are watered, a dry area exists under the windrow that can cause delaminations.

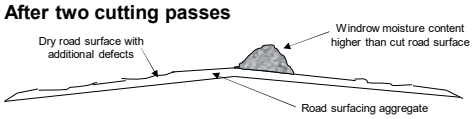
90

Surface Delamination

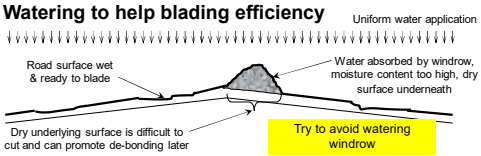
91

Avoid Watering Windrows

After two cutting passes



Watering to help blading efficiency



92

Streaking Problems

Water truck wheel tracks – water truck compacted loose gravel when applying water from back of truck – less penetration in wheel tracks

Lower moisture in wheel tracks where wheels compact loose gravel.

This problem also caused by a plugged nozzles on a water truck spray bar

93

Uniform Penetration with Front Spray Head

94

Blade Processing to Reduce Segregation

Goal: Consistent Moisture & Gradation

95

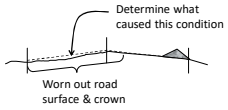
Cut Out Washboards on Existing Gravel

What problems occur when washboards are just filled in?

96

Re-Building Uneven Crown

- Salvage existing gravel, windrow on high side

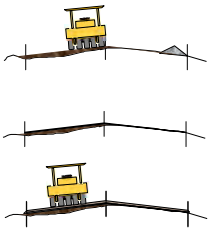


- **Options for Fixing Uneven Crown**
- Lower road by gravel cut and fill
- Haul in Pit Run
- Haul in new fill & mix in 2% cement

97

Re-Building Crown (Continued)

- Compact subgrade – water if necessary
- Correct drainage along shoulders and ditches
- Spread existing gravel from windrow
- Add new gravel and compact



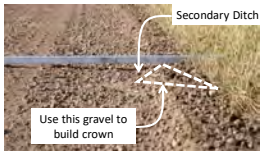
98

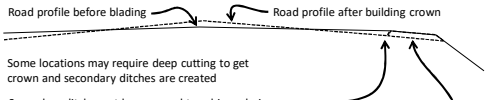
First Pass to Fix Crown

Minimal cutting at "toe" to avoid making secondary ditch

99

Blading Problems





Some locations may require deep cutting to get crown and secondary ditches are created

Secondary ditch must be removed to achieve drainage

If shoulder material contains good gravel, use it to build crown - if too much large rock or dirt, blade into ditch

100

Gravel Thickness

101

Evaluate Blading and Gravel Thickness

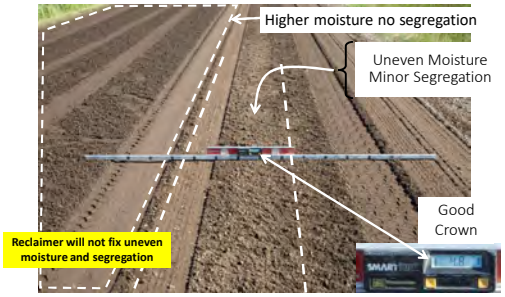
After building 5% crown, more gravel may be needed in some areas to keep from reclaimer from getting into the subgrade

102

Making Final Pass

103

Evaluate Moisture Consistency & Crown



104

Evaluate Moisture Consistency and Crown

105

New Gravel Placement, Shaping and Compaction (SP 892 Section C)

- Continuously monitor yield to confirm thickness
  - Suggest using 100% of modified density by T180. Also, remember to use wet density for spread calculations
- Add water to within 2% of optimum by Modified test procedure(T180)
  - Suggest moisture at optimum – gravel will hold together better and less water needed during chloride mixing
- Build a uniform windrow
  - Solving segregation problems at this point is much easier now than later
- Sample windrow for gradation acceptance (SP 892 Table 1, page 2)

106

New Gravel Placement - Continued

- Spread to the desired crown
  - Suggest spreading to 4.5% crown because chloride/gravel mix will flatten to 4%
- Compact to at least 95% of density by Modified test procedure(T180)
  - The higher you get density, the less likely you will have to reprocess prior to spreading chloride. Test for Compaction
- Incorporate calcium chloride within 14 days
  - Suggest spreading chloride within several days after placement to avoid having to reshape and process

107

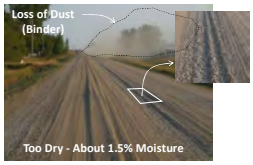
Low Moisture and Traffic Caused Segregation

108

Preventing Segregation During Gravel Placement

- Sand and gravel segregation is a major problem that significantly shortens gravel life, increases blading, etc.
- Prevent Segregation by:
  - Adding water to gravel before placement
  - Adding water prior to blading
  - Restrict traffic until blading & compaction is completed

Spread with 3% moisture is better, 5% even better yet

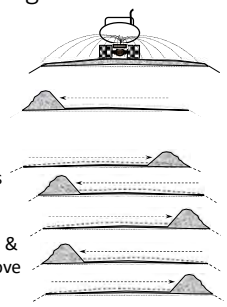


SP 892 Sec C: "….do not drive on placed gravel prior to windrow processing"

109

Blade Mix to Fix Segregation

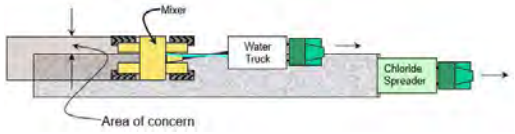
- Wet gravel to moisture above optimum during initial blading
- Windrow as much gravel as possible from one side of the road to the other and back.
- Repeat the windrowing and watering process as many times as necessary to remove segregation (> 4 times?)
- Reclaimers mix gravel, additives & moisture well, but will not remove longitudinal or transverse segregation.



110

Field Test to Show Reclaimer Mixing Limitations

1. Mix chloride off center to determine if cement is moved in transverse direction
2. After mixing for 20 feet, turn water off on left side of mixer to see if water is moved in transverse direction



2. Segregation, streaking and inconsistent moisture content problems are why blade mixing is required after mixing (SP 892 Section D.1. Paragraph 2).

111

112

Blade Processing

Goal: Consistent Moisture & Gradation

This dry gravel flows and segregates

This damp gravel does not segregate & compacts well

113

Water &"Over Compact"

- Extends crown life
- Less problems meeting compaction and ½" tolerance

114

Calcium Chloride Application

- Basic Info on Calcium Chloride
- Application Rates and Yield Test
- Spread Location and Alignment
- Spread Uniformity

115

Dry Chloride Moisture Absorption

- Chloride applied to dry road gravel

Moisture absorption takes about 20 minutes

Gravel and Chloride mixture takes 3 days to 2 weeks to cure (reach equilibrium)

- Chloride absorbed water from air

116

Application Rate Specs (SP 892 Sec D.1.b & D.3.)

- Target Spread Rate in Lbs. (100% Salt)/SY = (1.85% x 95% x 139 lbs/CF x 4/12 ft) x 9 = 7.3 lbs/SY

Use actual maximum density from Lab test

- Application Rate Ranges

Remember: Data in this table is based on 139 lbs/CF – use actual test data

Application Rate: % based on gravel density ("100% Salt")	Application Rate: Lbs/SY ("100% Salt")	Application Rate: Lbs/SY ("94% Salt")
1.7% Lower Limit	6.7 lbs/SY	7.2 lbs/SY
1.85% (Target)	7.3 lbs/SY	7.7 lbs/SY
2.0% Upper Limit	7.9 lbs/SY	8.4 lbs/SY

- Suggestions
  - If spread test are close to range and spread is uniform → do a Truck Load Yield Test
  - Determine yield on all spreads, continuously monitor uniformity

117

Example Truck Load Yield Test

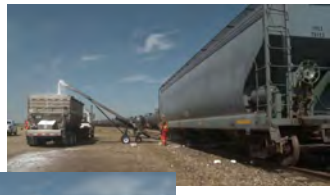
- Rate in lbs./SY = **Weight Chloride** applied to road, divided by **Area Covered**
- Example:
  - Weight Chloride→ 15 tons of 94% Concentration
  - Area Covered → (30 ft x 1150 ft) ÷ 9 SF/SY = 3833 SY
  - Application Rate of 94% → (15 x 2000)/3833 = 7.83 lbs/SY

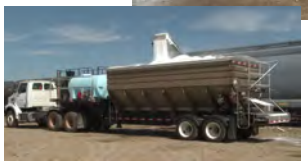
Application Rate: % based on gravel density ("100% Salt")	Application Rate: Lbs/SY ("100% Salt")	Application Rate: Lbs/SY ("94% Salt")
1.7% Lower Limit	6.7 lbs/SY	7.2 lbs/SY
1.85% (Target)	7.3 lbs/SY	7.7 lbs/SY
2.0% Upper Limit	7.9 lbs/SY	8.4 lbs/SY

Remember: Data in this table is based on 139 lbs/CF – use actual test data

118

Rail Car Unloading





119

Semi Trailer Delivery and Loading Dry Chloride

120

Centerline Alignment Berm

Marking centerline helps align spreader and reclaimer so that skips or excessive overlaps are avoided

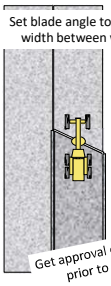
The height of the blade operator's eye and his operator skills help in marking centerline berm – critical for horizontal and vertical curves

121

Alignment & Spread Width Windrows

Small windrow at shoulder

Set blade angle to get correct width between windrows



"Small" windrow at centerline

Windrows define centerline shoulder & spread width

Get approval of spread location/width prior to chloride application

122

Spreading Chloride

123

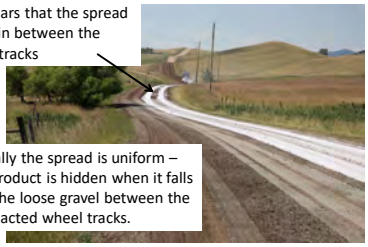
Spreading Chloride

The dry chloride spread must be to the top of the berm to get adequate centerline overlap.

124

Dry Product Spread Uniformity

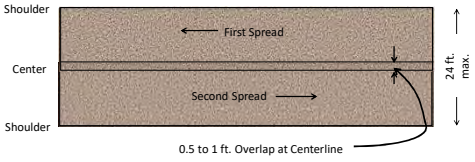
It appears that the spread was thin between the wheel tracks



Actually the spread is uniform – the product is hidden when it falls into the loose gravel between the compacted wheel tracks.

125

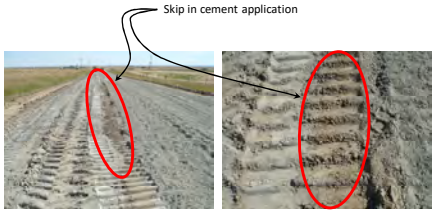
Spreading and Milling Plan



Remember: Shorten spread and reclaimer milling length in hot windy weather or when rains are possible

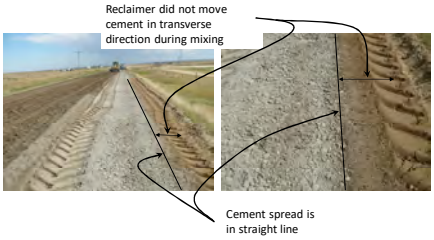
126

Application Skips Not Fixed by Reclaimer



127

Spread Overlaps & Skips Not Corrected by Reclaimer



128

Reclaimer Mix Chloride Four Inches Deep into Compacted Road Surface

- Uniform Mix Depth
- Starting void and ending hump
- 200 ft. Transitions
- Reclaimer Alignment and overlap
- Four Reclaimer Passes – SP 892 Section D.3 Paragraph 3.
- Uniform mixing water

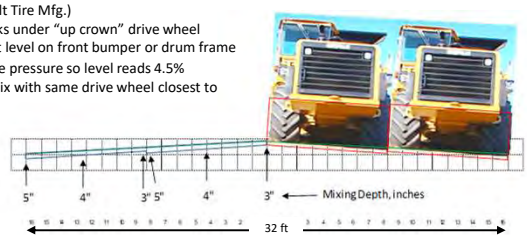
129

Uniform Mixing Depth on Crown w/Cat RM300

Same tire pressure → un-even depths

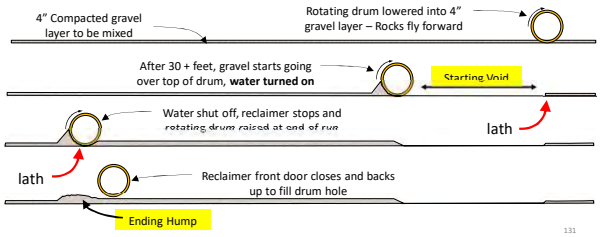
Suggestion: Adjust front tire pressures on concrete shop floor (Consult Tire Mfg.)

1. 3.5" blocks under "up crown" drive wheel
2. Put smart level on front bumper or drum frame
3. Adjust tire pressure so level reads 4.5%
4. Always mix with same drive wheel closest to centerline



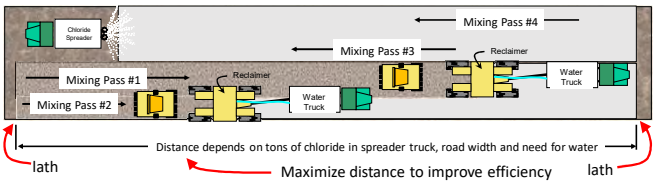
130

Starting Void, Ending Hump



131

Chloride Application and Reclaimer Mixing Plan



Turning Reclaimer around solves "void/hump" problem →

Rolling right behind reclaimer speeds the "curing" process

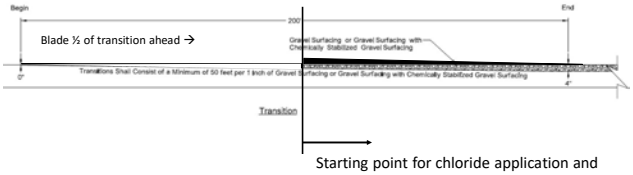
Stop spreading chloride before Noon each day

Blade must process and compact all mixed gravel by end of day (SP 892 Sec E.4.)

132

Transitions at Beginning and Ending of Treatment

Section No 20, Sheet No 2 of Plans



Starting point for chloride application and for mixing

133

Chloride Spread and Mix Plan

- Chloride Spreader: 15 tons on 30 ft wide road → 1154 ft
- 3000 Gallon Water Truck: 1% addition → 1895 ft

Water Truck Spread Length =
(3000 gal x 8.34 lbs/gal)/(1% x 30 ft x 4/12 ft x 95% x 139#/CF) = 1895 ft

134

The Mixing and Compaction Train

Compaction to start "curing" and allow limited traffic thru site

135

Uneven Moisture Contents

Double application of water where reclaimer runs overlap

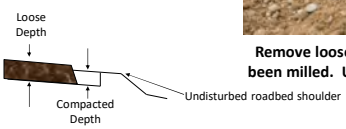
136

Milling Depth Check

Undisturbed reference surface outside milled area

137

Mixing Depth Check



Remove loose gravel next to shoulder that has not been milled. Use shovel or straight edge to measure depth of milling

138

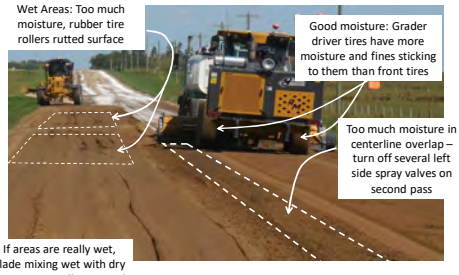
Mixing in Chloride & Water into Gravel

139

Moisture Content Indicators

140

Moisture Issues/Observations



141

Estimating Moisture

reclaimer operator can judge moisture by looking at amount of "pick up" on front tandem tire.

142

Longitudinal Segregation, Wet/Dry Streaks

Fix: Blade Mix

143

Reclaimer Operation Conclusions

- The Equipment Train – keep the equipment moving to reduce moisture loss and increase miles per day
- Alignment – Use centerline berm to prevent skips
- Depth – monitor depth and prevent subgrade contamination
- Moisture Content – Enough moisture to dissolve chloride avoid segregation and get compaction

144

Blade Processing Gravel and Chloride

- Objectives:
  - Improve uniformity of chloride and moisture content (Spec SP 892 Section D.1. ¶ 2)
  - Speed up curing

145

Blade Processing (SP 892 Sec D.1. ¶2)

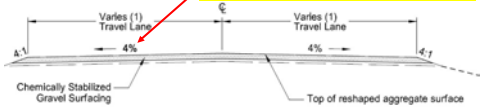
- "Process full depth and width"
- Cross section area: 4/12' x 32' x 1.25 = 13.3 SF (1.25 swell factor)
- Loose Windrow: 8 ft wide, 32" high → 1% below Optimum Moisture
- Concerns:
  - Cutting to the bottom of mixed layer
  - Contamination by cutting too deep
  - Compacted depth after finishing
  - Segregation if low moisture

Cat 14M, with 14' moldboard on 30° angle, 27" high

146

Shape to 4.5% Crown

Suggestion: Require 4 to 4.5% Crown

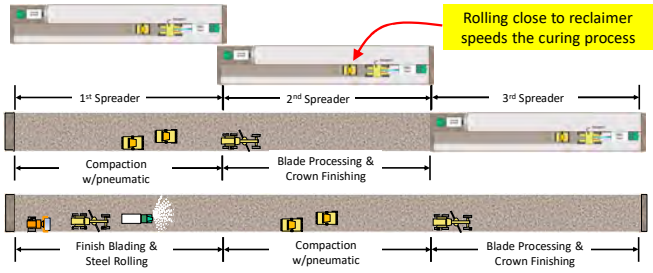


- 4.5% crown will be reduced during cure period
- Use slope meter as well as grade control on blade
- Blade operator directs watering and rolling

147

Blade Processing and Compaction Plan

Rolling close to reclaimer speeds the curing process



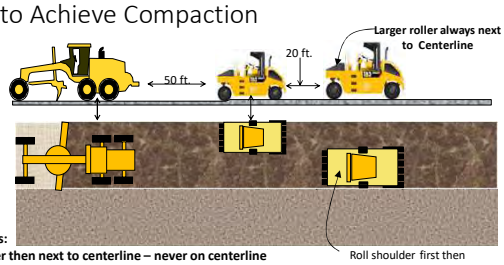
148

Compact with Rubber Rollers

- Normally roll from shoulder to centerline similar to hot mix
- Roller operators must have a consistent uniform pattern
- Increasing speed reduces compaction effort
- Rollers follow blade operators direction
- Know how many passes are needed to get compaction, but never stop rolling
- As rest of crew becomes more efficient, more rollers may be needed to keep up.
- Roller operators and finish blade are last to leave project – consider stagger start times.

149

Rolling to Achieve Compaction



Rolling Rules:
Roll shoulder then next to centerline – never on centerline
Never Stop Rolling
Roll next to centerline more than shoulders
Compaction Rolling speed is 3 to 5 mph

150

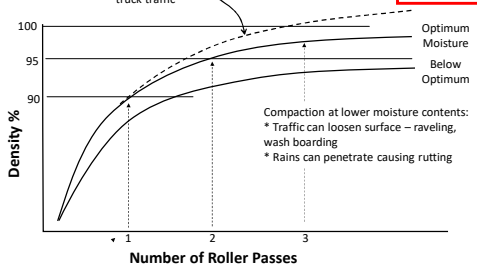
Compaction with Two Rollers

Speed should be 3 to 5 mph
Never stop compaction rolling - Gravel cannot be "over rolled" like asphalt
Density will increase with each pass
Less problems meeting ½" surface tolerance

151

Optimum Moisture

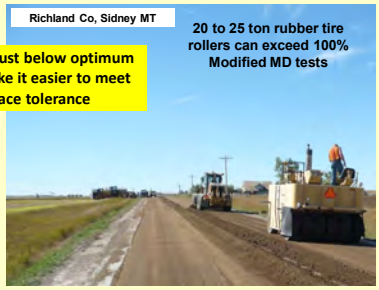
Why would you want to exceed 100% density?



152

Exceed Compaction Requirements

Excessive rolling just below optimum moisture will make it easier to meet the ½" surface tolerance



153

Finish Blading

Move as little gravel as possible but carry enough material on your moldboard to fill roller marks and rebuild crown

At transitions between mixing runs, blade 50 to 100 feet back into previous run to make a smooth transition

154

Finish Blading after Compaction

155

Watering and Last Pass in Finish Blading

156

Checking Crown after Finish Blading

157

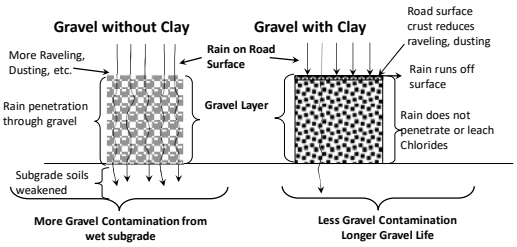
Building a Road Crust

- The benefits of a Road Crust during construction
  - Significantly reduces raveling/float
  - Less problems meeting ½" in 10 ft surface tolerance
- The process
  - Gravel should contain clay
  - Works best in hot weather
  - Light watering on compacted gravel
  - Pumping fines for road crust with rollers or other equipment
  - Surface normally dries out and sets up overnight

158

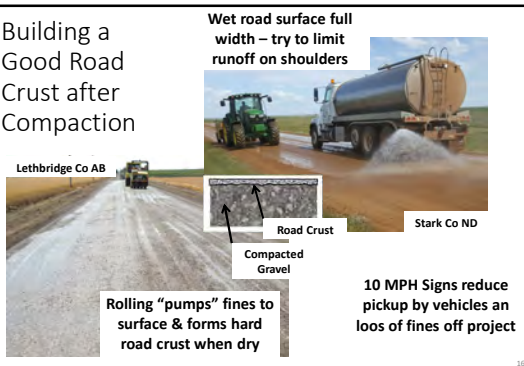
Clay Road Crust & Chloride Retention

- Clay fills voids in gravel, forms road crust, sheds rain, retains chloride, etc.
- Chloride keeps clay from dusting



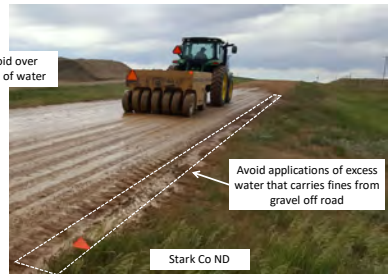
159

Building a Good Road Crust after Compaction



160

Water Application for the Road Crust



161

Light Watering to Pump Fines for Road Crust

162

Rolling Wet Gravel to Build Road Crust

With steel roller, use high frequency, low amplitude at 5 to 8 mph

Increase speed to the 5 to 8 mph

Johnson Co WY

163

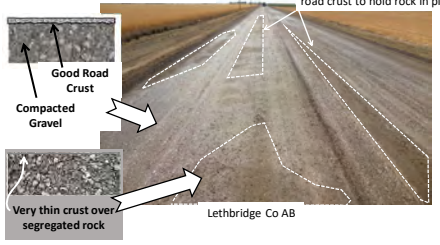
Building Road Crust

164

Road Crust Building Problems

Where segregation in gravel exists, it is impossible to build a uniform long life road crust

Areas that you should expect raveling of coarse rock – not enough road crust to hold rock in place.



Lethbridge Co AB

165

Good Road Crust

West Tensleep Road
Bighorn NF, Wyoming - 2006

166

Conclusions: Finish Blading and Building a Road Crust

- Finish Blading -
  - Very light blading
  - Articulate to compact crown
- Building a Road Crust
  - Light watering
  - Run rubber roller at 5 to 10 mph to pump fines **or**
  - Use steel vibratory at high frequency, low amplitude

167

Problems in the Finished Surface

- Untreated "Shadow" across road
- Untreated longitudinal streaks
- Potholes along centerline
- Longitudinal rutting parallel to centerline
- Intermittent raveling or wash boarding
- Surface delamination
- Hump in compacted surface at centerline

168

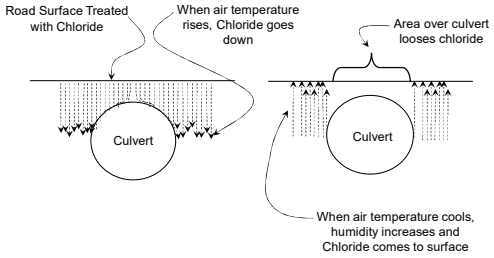
Untreated "Shadow" Across Road

- Cause
  - Shallow gravel thickness over culvert
  - Gravel with low clay content
- Fix Options
  - Add gravel to increase cover
  - Add clay to gravel

169

Chloride Movement in Roads

Chloride movement is vertical and follows moisture vapor



170

Untreated Longitudinal Streaks

- Causes:
  - Uneven watering prior to or during reclaimer mixing
  - Inadequate blade processing after reclaimer mixing
  - No overlap or skip between reclaimer runs, blade processing not done deep enough
- Equipment/Process changes
  - Improve water truck
  - Use blade to make alignment spread berms at centerline and shoulder
- Fix Options:
  - If condition doesn't improve in 48 hours, re-mix gravel with blade, add water if necessary and compact

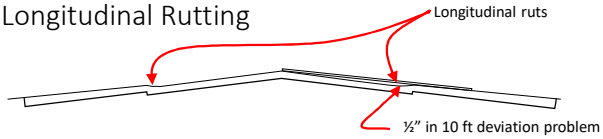
171

Potholes

- Cause:
  - Crown under 4%
  - Rollers flattening crown
  - Truck traffic is flattening crown
- Fix Options:
  - Build crowns at 4-1/2% to 5%
  - Monitor rolling operations, ensure gravel is close to optimum moisture
  - Change crown building practices
  - Build 4.5% crown and trim down to 4% after truck traffic.

172

Longitudinal Rutting



- Cause
  - Transverse mixing depth is different when using a reclaimer
  - High or low moisture content across mixing chamber on reclaimer
- Fix Options:
  - Check mixing depth on 4% crown, adjust tire pressure?
  - Deeper blade processing after reclaimer mixing.

173

Intermittent Raveling or Wash Boarding

- Cause → Segregation
  - Low gravel moisture when placed
  - Traffic is allowed over loose gravel layers
  - Water truck does not apply even application
- Fix Option
  - Increase moisture in gravel
  - Reprocess with blade from one side of the road to the other until segregation doesn't exist.

Lethbridge Co AB

174

Surface Delamination


Sheridan Co WY

- Cause:
  - Treated layer moves on dry subgrade → normally due to watering treated gravel when a windrow is covering part of the subgrade
- Fix Options
  - Do not water windrows
  - Blade up treated gravel in lane where problem exists, water subgrade, replace treated gravel and compact.

175

Hump in Compacted Gravel at Centerline

- Cause
  - Treated gravel moisture content too high – too much lateral movement during rolling
  - Too much material in one lane – a finish blading problem
- Fix Options
  - Lower moisture content in gravel
  - Lower amount of material in second lane during finish blading

176

"Critical" Construction Procedure Conclusions

- Develop a work plan, be prepared to modify
- Plan around wet weather
- Enough gravel to build 4.5% crown?
- Deal with segregation early
- Water is key to both segregation and compaction
- Get gravel close to optimum prior to spreading chloride
- Use blade to mark center line
- Check out reclaimer mix depth on crown & spray bar
- Reprocess mix depth & uniformity
- Exceed 100% compaction, never stop rolling
- Crown reduction during cure
- Steel roller helps meet ½" tolerance and build road crust
- Problems in the finished surface

177

Module 5: Quality & Quantity

- Quality & Quantity **Control – <u>Contractor's</u>** responsibility
- Quality & Quantity **Assurance – <u>Owner/Agency</u>** responsibility
- Suggestion:
  - Both parties must work together

178

Quality & Quantity Task List

- Road Preparation
  - Watering
  - Road surface crown (4%)
  - Gravel Thickness
  - Moisture Content
- Calcium Chloride
  - Quality
  - Concentration
- Calcium Chloride Application
  - Application rate (1.85%)
  - Uniformity
  - Width of spread
  - Yield measurement
- Mixing
  - Depth 3.5 to 4 inches
  - Width
  - Uniformity of gradation and moisture
  - Moisture (0% to 2% < optimum)
- Compaction and Shaping
  - Moisture (0% to 2% < optimum)
  - 95% Compaction
  - Crown (4%)
  - Surface Tolerance (½" in 10 ft)

179

Calcium Chloride "Flake"

- AASHTO M 144 Type S, Grades N1, N2 of N3, Class A

Solid 77% 90% 94% Flake

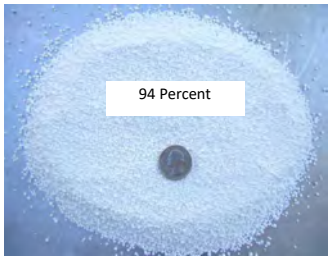
Concern: "100 percent salt" requirement should be in pay item description

Suggestion:
Delete the word "Flake",
Specify AASHTO M 144 Type S, Grade N3, Class B → "Solid 94% Pellet"

- Calcium Chloride Acceptance
  - Concentration → Manufacturers certificate Actual percentage is 94 to 97%
  - Visual Inspection SP892 F.1.: Look for clumping

180

Dry Calcium Chloride



Dry Pellets

Time = 0 minutes

Moisture Absorption from Humidity

Time = 20 minutes

Dry Calcium Chloride can absorb 10 times it's weight in water

181

Laboratory Compaction Testing

- SP 892 Section A.1. Tests on newly crushed aggregate
  - Moisture Density Test by ND T180 (Modified Proctor) with and without 1.85 percent Calcium Chloride
  - Optimum Moisture during mixing is optimum to minus 2%
  - Minimum Density is 95% of maximum
- SP 892 Section A.2. (Same as A.1. except with In-Place Aggregate from Sites G11 and G08N)

Suggestion: make sure lab has representative sample of aggregate to that corresponds to the average gradation and PI shown on Power Point Slide 10 and 12

182

Existing Gravel Road Reshaping to 4%(?) Crown

- SP 892 Section B paragraph 4: 0.04'/' = 4%
- Suggestion: Use smart level and 1" square 10 ft aluminum straight edge (same device used for surface tolerance)

- Suggestion: Measure crown and gravel depth prior to shaping to make sure enough gravel exists to build crown Do this now!!

183

Additive Application

- Application Rate
  - Use Geotextile over full width of application
  - Measure area covered
  - Weigh amount applied

184

Application Rate Specs (SP 892 Sec D.1.b & D.3.)

- Target Spread Rate in Lbs. (100% Salt)/SY = Use actual maximum density from Lab test

(1.85% x 95% x 139 lbs/CF x 4/12 ft) x 9 = 7.3 lbs/SY

- Application Rate Ranges

Remember: Data in this table is based on 139 lbs/CF – use actual test data

Application Rate: % based on gravel density ("100% Salt")	Application Rate: Lbs/SY ("100% Salt")	Application Rate: Lbs/SY ("94% Salt")
1.7% Lower Limit	6.7 lbs/SY	7.2 lbs/SY
1.85% (Target)	7.3 lbs/SY	7.7 lbs/SY
2.0% Upper Limit	7.9 lbs/SY	8.4 lbs/SY

- Suggestions
  - If spread test are close to range and spread is uniform → do a Truck Load Yield Test
  - Determine yield on all spreads, continuously monitor uniformity

185

Example Truck Load Yield Test

- Rate in lbs./SY = **Weight Chloride** applied to road, divided by **Area Covered**
- Example:
  - Weight Chloride→ 15 tons of 94% Concentration
  - Area Covered → (30 ft x 1150 ft) ÷ 9 SF/SY = 3833 SY
  - Application Rate of 94% → (15 x 2000)/3833 = 7.83 lbs/SY

Application Rate: % based on gravel density ("100% Salt")	Application Rate: Lbs/SY ("100% Salt")	Application Rate: Lbs/SY ("94% Salt")
1.7% Lower Limit	6.7 lbs/SY	7.2 lbs/SY
1.85% (Target)	7.3 lbs/SY	7.7 lbs/SY
2.0% Upper Limit	7.9 lbs/SY	8.4 lbs/SY

Remember: Data in this table is based on 139 lbs/CF – use actual test data

186

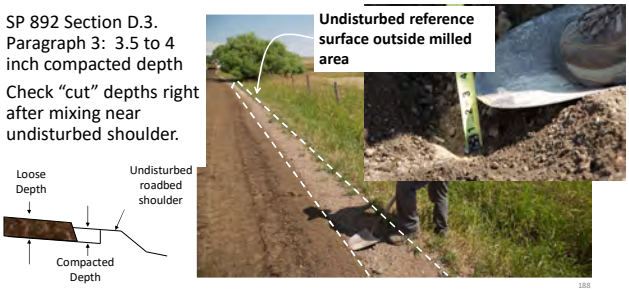
Chloride Application Rate

- Application Rate Checks
  - Visual evaluation
  - Spread test
  - Yield test

187

Mixing Depth Check

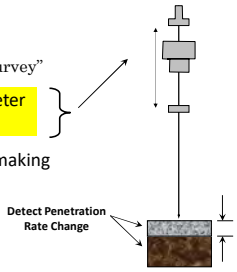
- SP 892 Section D.3. Paragraph 3: 3.5 to 4 inch compacted depth
- Check "cut" depths right after mixing near undisturbed shoulder.



188

Final Depth Check After Blade Mixing, Crown Building and Compaction

- SP 892 Section D.3. ¶ 3:
  - Spec calls for "pre and post placement survey"
- Suggestion: Use Dynamic Cone Penetrometer (DCP) – if problems suspected, dig holes
- Another approach: Estimate depth while making pilot holes for nuclear gage testing



189

Surface Tolerance Check

- SP 892 Subsection E.5. Finishing: ½" in 10 feet
- Consider the following:
  - Will water drain down crown or down the road?
  - How large is the problem?
  - Will the problem area get worse? Remeasure after 7 days?
  - Put off making a decision until 15 days after stabilization?
  - Can the tolerance be meet by watering and vibratory rolling?

190

When to Rip and Process Full Depth (4 inches)

Do Not Rip Up and Reprocess. Accept, even though ½" exceeded at two locations

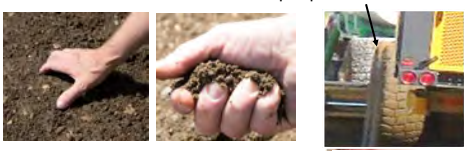
Reject → Pot Holes likely for extended length of road, ½" surface tolerance exceeded in multiple locations

Suggestion: Surface tolerance may be improved by water and steel roller

191

Estimating Moisture

reclaimer operator can judge moisture by looking at amount of "pick up" on front tandem tire.



Excess moisture on hand - note sheen on particles

Too dry, material does not stick together

Close to Optimum Moisture – no sheen, material sticks together

192

Checking Crown after Finish Blading

193

Quality & Quantity Task List

- Road Preparation
  - Watering
  - Road surface crown (4%)
  - Gravel Thickness
  - Moisture Content
- Calcium Chloride
  - Quality
  - Concentration
- Calcium Chloride Application
  - Application rate (1.85%)
  - Uniformity
  - Width of spread
  - Yield measurement
- Mixing
  - Depth 3.5 to 4 inches
  - Width
  - Uniformity of gradation and moisture
  - Moisture (0% to 2% < optimum)
- Compaction and Shaping
  - Moisture (0% to 2% < optimum)
  - 95% Compaction
  - Crown (4%)
  - Surface Tolerance (½" in 10 ft)

194

Module 6: Maintenance of Chloride Stabilized Gravel

- Blading frequency
- Maintenance blading stabilized gravel
- Correct moisture content
- Removing defects and processing gravel
- Rebuilding crown
- Compaction
- Rebuilding road crust
- Chloride surface applications

See Module 4: Construction Procedure

Note: Many thanks to County blade operators that have shared what works well and what does not.

195

Blading Frequency

County	Hrs./Mile/yr.	
	Untreated	Treated
Cascade	6.5	0
Fergus	2.5	1.25
Judith B	8	2
Teton	6.6	4.4
Average	5.9	1.9

Conclusion: Treated gravel needs 1/3 the blading

From 2017 MT Missile Rd Report

Exhibit 6-15 Untreated Maintenance Survey Results

	County	Maintenance frequency	Equipment			Time
		Times per Season	Blade	Compaction	Water	Hours/Mile
Untreated Roads	Cascade	2 to 3	X		Rain	2.5
	Fergus	2	X	(W/R)[1]	Rain	1.25
	Judith Basin	3 to 5	X	(W/R)[1]	Rain/Water Truck	2
	Teton	2	X	(W/R)[1]	Rain	3.3

[1](W/R): Walk 'n' Roll type compactor attached to the motor-grader.

Exhibit 6-16 Treated Maintenance Survey Results

	County	Maintenance frequency	Equipment			Time
		Times per Season	Blade	Compaction	Water	Hours/Mile
Treated Roads	Cascade	-	-	-	-	-
	Fergus	1	X	(W/R)[1]	Rain	1.25
	Judith Basin	0[2]	X	(W/R)[1]	Rain/Water Truck	2
	Teton	1	X	(W/R)[1]	Rain	4.4[3]

[1] Walk 'n' Roll type compactor attached to the motor-grader.
[2] Treated road constructed 2011 did not need maintenance for 3 years after construction. Only spot maintenance has been done since 2014.
[3] Occasionally treated roads are processed deeper to incorporate $CaCl_2$ from below surface.

196

Maintenance Blading Stabilized Gravel

- Do not break road crust unless:
  - Traffic speed is slowed significantly
  - Pot holes and loose rock are a safety hazard
  - Rebuilding crown or adding more chloride ii necessary in the Spring
- Summer Blading when defects are significant
  - Avoid if possible
  - If just raveling or light washboards, try watering at night
  - If blading is necessary, pre-water at night
- Fall Blading when defects are significant or crown flattened
  - Will reduce spring blading
  - Will extend gravel life
- Other Concepts
  - Less blading extends gravel life
  - Road crust extends gravel and chloride treatment life

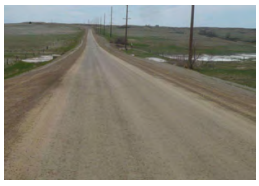
197

Loose Rock on Stabilized Gravel

- Causes of Loose Rock
  - Gravel top size over ¾"
  - Poor gradation, fracture, low clay content or combination of all
  - Gravel dry/segregated during initial placement

These problems are from crushing and initial placement

- Need for Blading
  - Usually not necessary until spring
  - Don't break road crust to incorporate loose rock
  - Loose rock could be snow plowed off road
- When to Blade
  - Spring for sure
  - Fall if moisture conditions favorable



198

Dirt Tracked onto Stabilized Surface

- Tracked Dirt will increase slipperiness, reduce chlorides in gravel and cause complaints from road users
- Remove dirt as soon as possible to reduce bonding to the treated surface.
- Do not water prior to blading

Lethbridge Co AB

199

Dusting - Top Treating Roads Previously Treated

The need for a top treatment of calcium or magnesium chloride depends on:

- Signs of residual chloride in early spring:
  - No top coat if road looks wetter in morning than afternoon
  - No top coat if road surface is very tight
- Expected weather conditions through summer months
- Expected amounts and type of traffic
- Availability of truck driver and water truck for night watering in late July & August
- Value of gravel versus cost of top treatment
- Potential for unbearable public relations event

200

Retreatment Options

- In-place mix more chloride with blade
- Calcium or Magnesium Chloride top treating
  - Whole road or
  - Problem areas
- Add clay to in-place gravel over whole road or just problem areas (clay will improve chloride retention, reduce washboards, etc.)

201

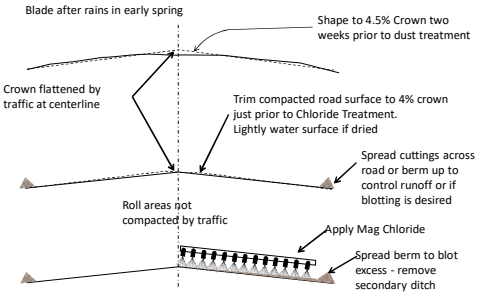
Try Extending Chloride Performance

- Light watering (1500 gal/mi) once a week at night
  - Raises humidity at road surface
  - Night watering:
    - Reduces evaporation by 60 to 70%
    - Humidity stays near chloride surface long enough to be captured by Chloride treatment
    - Few traffic interruptions at night
- Evaluation
  - Compare results with road sections not watered
  - Water some segments at greater rates to compare results
  - Increase rates where dusting appears worse

Johnson Co WY

202

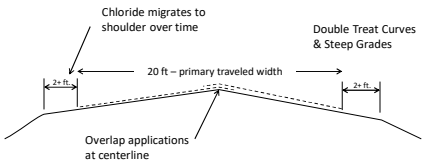
Spring Blading to Build Crown



Johnson Co WY

203

Chloride Application Techniques



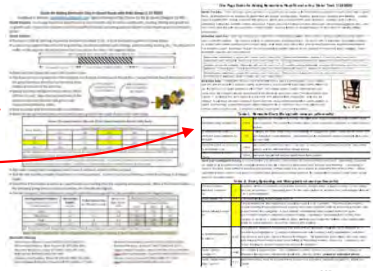
If treatment is sticking to tires, lightly water road surface

204

Improve Chloride Performance by Adding Clay to Gravel

One page guides available:
stevemonlux@gmail.com

- Consider adding clay if:
  - Percent Pass #200 and Plasticity Index Sum is less than 20
  - Stabilized gravel starts dusting by early August.
- Belly Dump Method:
- Water Truck Method:



205

Module 7: Conclusions

- Expected Performance
  - Sites G11 and G08N – Stabilization of existing gravel
    - Raveling and wash boarding will decrease
    - Performance will not be as good as Sites D-3 and C-10
  - Compare past performance to the treated gravels
  - The first work will likely perform worse than the last work as the construction process becomes more refined.
- Performance Measurements – start a simple monitoring plan
- Construction Equipment
  - Consider minor changes to water trucks, blades and the reclaimer
  - Use heavy self propelled rubber rollers to improve efficiency

206

Module 7: Conclusions (Continued)

- Construction Procedure
  - Continuous moisture monitoring is very critical-
  - Building 4.5% crown should make meeting the 4% crown realistic
  - Blade processing the gravel/chloride mixture is critical to meeting compaction and surface tolerance requirements
  - Non-stop rolling and building a road crust will help meet the ½" tolerance.
- Quality Control and Quality Assurance
  - Timely coordination between contractor ground man and agency testing personnel is critical
  - Continuous monitoring of moisture, mixing depth, compaction and crown is critical.
- Maintenance of Chloride Stabilized Gravel
  - Do not blade unless defects make traffic speed slow significantly
  - Spring and fall blading is critical
  - Rebuilding road crust is critical were gravel contains clay.

207

Additional Questions or Comments?

Thank You !!

208