65th Annual Idaho Asphalt Conference University of Idaho, Moscow, Idaho October 22-23, 2025



Conference Program

Wednesday, October 22, 2025					
1:00 -	Workshop "Best Practices for Mill & Inlay Asphalt Pavements" Presented by Western				
5:00 pm	States Equipment / Caterpillar. Separate registration is required				
4:00 pm	IAC registration opens				
5:00 -	to book of the title House Construction of the Market Construction of the Construction				
7:00 pm	Icebreaker in Exhibit Hall – Sponsored by Western States Equipment / Caterpillar				
Thursday, October 23, 2025					
7:00 am	Registration opens – Continental Breakfast in Exhibit Room				
8:00 am	Opening Comments				
	Dr. Emad Kassem, PE, Professor, University of Idaho				
8:15 am	Welcome Remarks				
	Dr. Suzanna Long, PE, Dean of College of Engineering, University of Idaho				
D. // !	- Consider Afternoon Consider				

Dr. Suzanna Long, PE, Dean of College of Engineering, University of Idaho					
Morning Session		Afternoon Session			
Presiding	Dave Johnson, PE The Asphalt Institute	Presiding	John Arambarri, PE Idaho Transportation Department		
8:30 am	Quality Control in Pavement Construction: Lessons Learned and Emerging Practices Dr. Adam Hand, PE University of Nevada, Reno	1:45 pm	Optimizing HMA Operations: From Production to Field Compaction Dave Johnson, PE The Asphalt Institute		
9:30 am	Montana's Experience with SMA and HiMA: Demonstration and Discussion Dave Johnson, PE The Asphalt Institute	2:20 pm	Cold In-Place Recycling: Techniques and Performance Insights Dr. Adam Hand, PE University of Nevada, Reno		
10:15 am	Break	3:00 pm	Break		
10:40 am	Applying Balanced Mix Design in the Field: Insights from North Dakota Zane Hartzog, PE National Asphalt Pavement Association	3:15 pm	Extending Asphalt Pavement Life: From Rejuvenation to Reflective Crack Mitigation Dr. Michael Vrtis, PE Minnesota DOT		
11:20 am	Project Delivery in Practice: DOTs vs. Local Agencies Mike Skinner, PE Asphalt Pavement Alliance	4:00 pm	Implementing Asphalt Rubber Chip Seal Technology for Pavement Preservation Tyler M. Palmer, MPA City of Moscow, ID		
Noon – 1:45 pm	Lunch and Expo	4:45 pm	Adjourn		



Speakers of the 65th Annual Idaho Asphalt Conference, Oct. 23, 2025

From left to right: Michael Vrtis, Muhammad Zubery, Mike Skinner, Emad Kassem, John Arambarri,

Zane Hartzog, Adam Hand, and Dave Johnson.

Not pictured: Tyler Palmer

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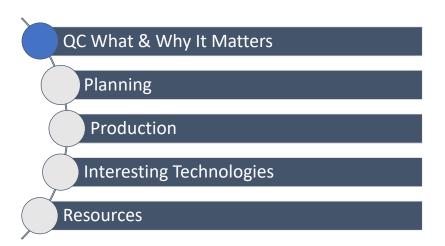
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QUALITY CONTROL IN PAVEMENT CONSTRUCTION: LESSONS LEARNED AND EMERGING PRACTICES





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WHAT DRIVES QC

Code of Federal Regulations:

23 CFR 637 Subpart B -

Quality Assurance Procedures for Construction

Policy: **Quality Assurance** (Non-Regulatory Supplement to 23 CFR 637) July 2006

- 23 CFR 637B permits use of Contractor test data for construction materials acceptance
- As long as DOTs validate the Contractor data with independent test results













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RISK MANAGEMENT

- Agency Risk
- Supplier Risk
- Contractor Risk

- Statistical Risk
- Engineering/Performance Risk



/

6 CORE ELEMENTS OF A QA PROGRAM



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WHY IS A QA PROGRAM IMPORTANT?

- QA is defined as "All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service"
 - Important for: DOTs, Contractors & Taxpayers
 - Responsibilities Assigned to Different Parties
- AASHTO R-10 Acceptance Plan Definition "...agreed upon process for evaluating the acceptability of a lot of material. It includes: lot size and sample size (i.e., number of samples), quality measure, acceptance limit(s), evaluation of risks, and pay adjustment provisions"
- Risks Exist!
 - DOT
 - · Producer, Contractor
 - Statistical
 - · Engineering
 - Performance











QA PROGRAM: CONTRACTOR QUALITY CONTROL (QC)

- Materials sampling, testing & inspection
- If part of acceptance decision
 - Independent of agency verification
 - Qualified technicians
 - Qualified laboratories
 - Independent assurance evaluation



See 23 CFR 637.207(a)(1)(ii).









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WHO CONTROLS QUALITY

- Who Controls It?
 - QC Manager
 - Inspector
 - Technician
 - Assurance Representative
 - Owner
- Who is Responsible for It?
 - Same Person(s)?











WRONG QUESTION - WHO MAKES THE PRODUCT?

- Superintendent
- Foreman
- Operators
- Laborer
- Manufacturer
- Subcontractor
- Only PEOPLE that MAKE a Product can Control the Quality of It!











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QA PROGRAM: AGENCY ACCEPTANCE

- Verification sampling, testing & inspection
- Quality evaluation
- Acceptance & payment
 - May include contractor test results if validated ...



See 23 CFR 637.205(d) and 637.207(a)(1)(ii)(B).











QA PROGRAM: TECHNICIAN QUALIFICATION

- Technician Qualification
 - Required for all sampling & testing in acceptance decision
 - Qualification programs
 - State programs
 - Regional partnerships
 - National programs

Qualified Technicians in the Room?













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QA PROGRAM – LABORATORY ACCREDITATION

- Accreditation required (AASHTO re:source, CMCE, L-A-B)
 - Agency central lab
 - Consultant dispute resolution labs
 - Consultant independent assurance labs
- Qualification required (AASHTO re:source, CMCE, L-A-B or SHA)
 - Testing labs used in acceptance decision
 - · Agency verification testing
 - Contractor QC testing

Work in Accredited Labs?

See 23 CFR 637.209(a)

US.Department of Transportation









QA PROGRAM: INDEPENDENT ASSURANCE

- Evaluate all acceptance sampling & testing
- Separate from acceptance testing
- Technician procedure evaluation
- Testing equipment evaluation
- DOT Role

State DOT IA Program?





See 23 CFR 637.207(a)(2) and 637.209(b).











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QA PROGRAM: DISPUTE RESOLUTION

- Required when contractor data used in acceptance decision
- Documented process
- Address discrepancies in
 - Agency verification testing
 - Contractor QC testing

Acceptance = QC

Been Involved in Dispute?

See 23 CFR 637.207(a)(1)(iii) and 23 CFR 637.205(a).











BETTER UNDERSTANDING THE TERM "QUALITY ASSURANCE"



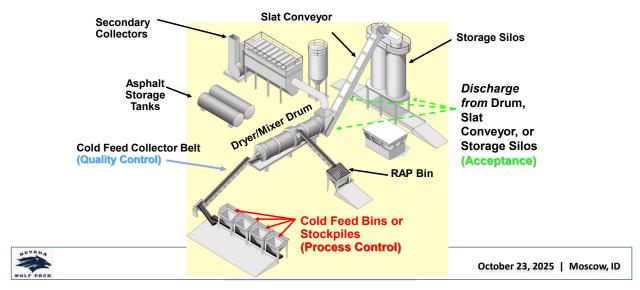
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PROCESS CONTROL

- A method for keeping a process within boundaries and/or the act of minimizing the variation of a process
- Voluntary part of the QA program that could include sampling, testing, inspection, etc.
- Responsibility of the Contractor
- PC is NOT used in the Acceptance Process



PC VS QC VS ACCEPTANCE - GRADATION



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DISTRIBUTING RISK



CONSIDERATIONS FOR MEETING QA REQUIREMENTS

- Entity Role(s) & Responsibilities in QA Program
 - Binder Production, Agg Production, Plant Production, Paving
- External Elements
 - Know Requirements
 - Fulfill Them
 - Leverage Them for Innovation and Competiveness
- Internal Elements
 - Management Support
 - Resources
 - People, Facilities, Equipment
 - Culture: Core Values, Policy, ...
 - Systems Approach Best Practice











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QC PERSONNEL

- Adequate and Well Qualified Staff
 - Technicians, Inspectors, Operations Supervisors, Engineers, Quality Managers
 - Continual Technical Development & Training

Certified Technicians?

QC Staff Post - QA Specs











QC LAB FACILITIES & EQUIPMENT

• Spec Responsibility Changes - Drives Resource Demands

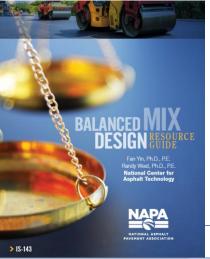


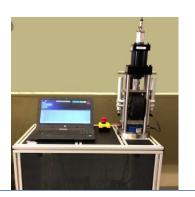
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BALANCED MIX DESIGN

- Performance Tests Correlated to Performance (Go vs. No-Go)
 - HWTD, Ideal-CT, ...







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EVOLUTION OF TRANSPORTATION CONTRACTOR QC

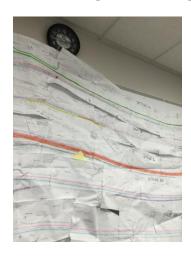
CONVENTIONAL PROCUREMENT

	Specification Type and Time Period (years)						
Resources	Method		Quality Assurance		PRS		
	1970	1995	1995	2020	20	2050	
Personnel	None	Tech	QCM _{HS} , Tech	QCM _{PE} , Tech(s) Schill-Set51 Ce51 umetrics / Index Contractor Routine	isk (s)	QCM _{PE} , Eng(s) _{MS,PE} , Techs	
Facilities	None	POD	Shed	Skill-sels	Large labs	Corporate and Regional	
Equipment	None	Raw Material	Volume	umetrics / Index	Index / Performance	Performance Based	
Support	DOT	Consultante	ities Lants	Contractor	Universities Consultants	Consultants Contractor	
QC	None	Resports	Required Signif Δ	Routine	Required Signif Δ	Required	
QC Activity	N	Intro Basic T& I	Basic T & I	T & I Index?	Advanced T&I Index	Routine Performance	

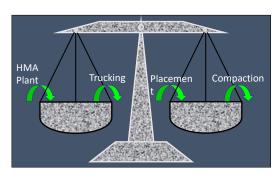
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IT'S BID DAY WHAT IS THE BASIS OF YOUR ASPHALT PAVING ESTIMATE?



- Paving Plan
- · Hot plant output
- · Paving width
- · Length of haul
- · Traffic control
- Number of trucks
- · Wide Paving Ext
- · Specifications
- Crew Wages
- Asphalt tonnage, \$/ton
- Owner



Balancing Operations = Uniform Production = Quality = Good Performance = Jobs = \$









ASPHALT PAVEMENT CONSTRUCTION PLANNING





What it is going to take to successfully build the project safely, in spec, on time, within budget and have it accepted?



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PAVING PLANNING – SIMPLE?

- Critical Path
- Communication
- Internal and External Comms
- Permits
- Mix Design
- Submittals & Approvals
- Utility Locators
- ROW?
- Hot Plant or Supplier
- Trucking
- Paving Crew

- QC Plan
 - · Sampling, Testing, Inspection
- Subcontractors
- Paving Plan
- Traffic Control Plan (MOT)
- Safety Plan OSHA & MSHA
- Storm Water Pollution Prevention Plan (SWPPP)
- Public Information
- Risk Matrix & Contingency Plan









CONTINGENCY

- In Planning do you ask
 - "What If..."
 - "...and if so, what can or will be done?"
 - Weather
 - Traffic Accident
 - Plant or Paving Equipment Breakdown
 - Sick Foremen
 - Inspection Identified Shutdown













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COMMUNICATIONS ARE KEY

- Opportunity to Get Things Right
 - Project
 - Team
 - Agencies
 - Suppliers
 - Neighbors...
- Communication Means... **Sharing Information**











IMPROVING COMMUNICATIONS

- Critical part of project planning and organization
- Speak clearly
- LISTEN carefully
- Summarize the conversation
- Make notes and share with participants if appropriate - Meeting Minutes & Action Items
- Partnering is intended to assist project teams with setting goals, resolving disputes and improving project outcomes















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PRE-CONSTRUCTION & PRE-PAVING MEETINGS

- Agency Input
- Contractor Input
- Project Personnel
- Testing
- Safety
- Utilities
- Cities or Municipalities
- Suppliers

- Who has What Responsibilities
- Who will Do What
- Paving Rate *Is Key Driver*
- On the List
 - Production
 - Safety
 - Environmental
 - Quality











PAVING PLAN

- Different Agencies/Entities different requirements
- Defines paving operations
- Phasing
- Preparation
 - Base or Mill/Fill
 - Prime or Tack
- Materials
- Trucking
- Equipment
- Paving & Compaction Production
- SHEQ
- Logistics, Logistics, Logistics

When Does the Mix Design have to be Started to pave the week of October 1st?







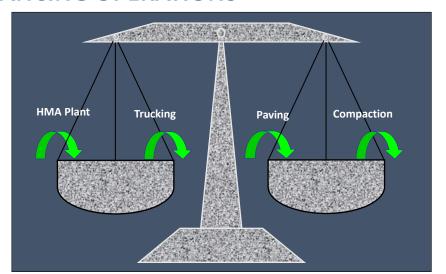




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BALANCING OPERATIONS











HOT PLANT QC ITEMS

☐ Scale & Plant Calibration Current? ☐ Last Coldfeed Calibration & Agg Changes?, No 🄞 , Yes Verify/Calibrate ☐ Filler, Fiber, Baghouse Fines... Calibration & Feeding 🗖 Asphalt Binder Flow Meter Calibration & Binder Changes?, No 👍 , Yes PG Changes &/or Temperate Changes: Yes, Verify/Calibration w/SG & Same for Fillers, Fibers, ... ☐ JMF vs. Mix Design in Plant Controls (Proportioning), Changed Bin %'s Yesterday-Was is Saved in the Controls? ☐ Stockpile Moistures Before Start Up ☐ Walk Plant Inspecting Scalping Screens on Feed Bins, Bin Dividers/Contamination, Agg & RAP Material Flow, Build Up at Chutes, ... Cameras Coldfeed or Hot Bin Gradations ☐ Mix Coating, Temperature, and Moisture on Discharge from Drum, Pugmill or Silo (Truck Samples) ☐ Any Moisture on Scales, Does OGFC Flatten with Truck Brake Released? ☐ Consistently get Representative Samples from? Drum Discharge, Silo Discharge, Trucks, ... QC - Mix %AC & Gradation....Gmm for Nuclear Gauge Correlation, %AV, VMA... and BMD Rutting & Cracking ☐ Truck Loading to Minimize Segregation (End vs. Belly Dumps) ☐ Plant Production vs. Loadout/Truck Tickets & Wasted/Storage Tons ☐ Paving Superintendent or Foreman - Be Honest with Plant Operator on Tonnage/Cutoffs or Pay for Waste ☐ Safety of Crew and Traveling Public

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PAVING QC ITEMS

- ☐ Paving Equipment Clean Truck Beds, Pickup Machine, MTV, Paver, Rollers, Lutes, Shovels
- ☐ Bio Release on Equipment, Pneumatic Tires, No Diesel Clean Surfaces
- ☐ Prime Coat or Tack Coat Application Rate, Uniform Application, Break
- ☐ Proof Roll Water Truck or Paver Bogey's Ever Use ICT CMV for Soft Subgrade or Utilities?
- ☐ Pickup Machine / MTV Clean Mat
- ☐ Test Strips for Density Targets
- ☐ Layout Longitudinal Joints stringline paint is simple & effective
- ☐ Paver Setup Paving by the Numbers & Matching Takeoff and Joints
- ☐ Paver Setup Screed Extensions, Auger Extensions, Screed Crowns / Breaks, Thickness with Rolldown ¼"/1"?
- ☐ Paver Setup Automated Grade Controls
- ☐ Time Available for Compaction MultiCool/PaveCool

https://www.asphaltpavement.org/expertise/engineering/resources

- ☐ Breakdown Rollers 3 Pass Max/Coverage, 1 or 2 or X Rollers if Echelon Paving; Pneumatic Breakdown Roller?
- ☐ Breakdown Rollers Amplitude and Frequency 1ipf, 10 to 14 ipf...
- ☐ Pneumatic Rollers Size, Ballast, Tire Temp, Tire Pressure, Skirting, Release, Release, Release
- ☐ Truck Dumping or Spreading (End vs. Belly Dumps) Taper and Backup Belly's More Uniform Windrow Temps
- 🗖 QC Sampling, Testing and Density Core / Nuclear Gauges, DPS Correlation (Pucks or Cores) Leverage Your QC Staff









PAVING QC ITEMS

- ☐ Constantly be Inspecting the Mat Behind Paver for Defects
 - ☐ Identify & Correct Defects, Leveraging QC Staff
 - ☐ See Mat Defects, Causes and Cures
 - ☐ Rework is Far more Expensive than Corrective Action While Paving
- ☐ Leverage Confinement for Density
- ☐ Compact Up Slope
- ☐ Compact Up Grade
- ☐ Compact Joint First Pass on Hot Side 4-6" Off Joint, Pinch with 1 Pass Cold Side Static
- ☐ ICT is very helpful Pass Mapping, Temp / Thermal Profile, DSP Density (up to full mat)
 - ☐ Combined Are Very Effective for Quality
 - ☐ Combined Are Very Effective for Bonus Capture
 - ☐ Combined Are Very Effective for Training Purposes
- ☐ Safety of Crew and Traveling Public









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CLEAN BED & RELEASE AGENT













SPRAY PAVER

- Tack Coat Applied with Paver
- Emulsion Tank on Paver
- Spray Bar on Paver
- Engineered Emulsions
- No Tracking











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TACK COAT APPLICATION









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TACK COAT PICKUP & TRACKING



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COLDMILLED SURFACES



BELLY DUMP WINDROW & MTV













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MTV PICKUP WITH PAVER HOPPER EXTENSION











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END_DUMPING INTO PAVER





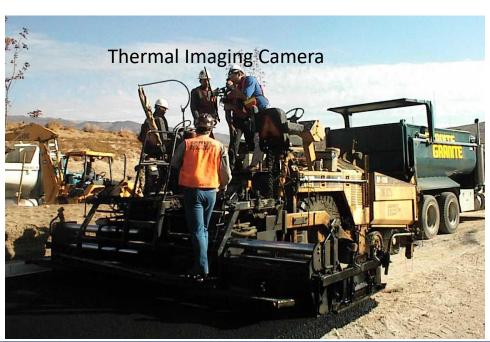






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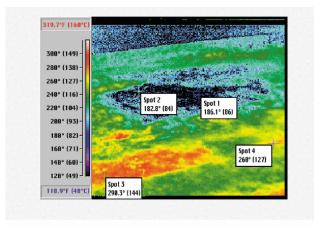


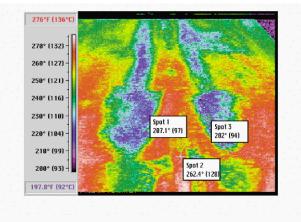




ET-481-46October 23, 2025 | Moscow, ID

TEMPERATURE SEGREGATION





BEHIND CATERPILLAR 1055B PAVER

USING BLAW-KNOX MC-30



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SAMPLING BEHIND THE PAVER

- Density Test Before Sampling...
- Will it Ravel?







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Mat Defects - Troubleshooting CAT Wavy Surface - Short Waves (Ripples) XXXXX Wavy Surface - Long Waves X Tearing of Mat - Full Width XXXXXX X Tearing of Mat – Center Streak V V × Tearing of Mat - Outside Streaks V VV ~ × Mat Texture - Nonuniform V V V V XX XXX Screed Marks XX Screed Not Responding to Correction VV X XXX XX Auger Shadows Poor Precompaction X X × 1 Poor Longitudinal Joint VV 1 X × Poor Transverse Joint × × Transverse Cracking (Checking) XX XX XX X X X X XX XX Mat Shoving Under Roller Roller Marks Poor Mix Compaction XXXXX XXX Procedure for Using Table NOTE: Many times a problem can be caused by more than one item, therefore, it is important that each cause listed be eliminated to assure solving the problem. 1. Find problem above. Caterpill 2. Checks indicate causes related to the paver. X's indicate other problems to be investigated. © Caterpillar 2019 All rights reserved.

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BREAKDOWN & INTERMEDIATE ROLLING







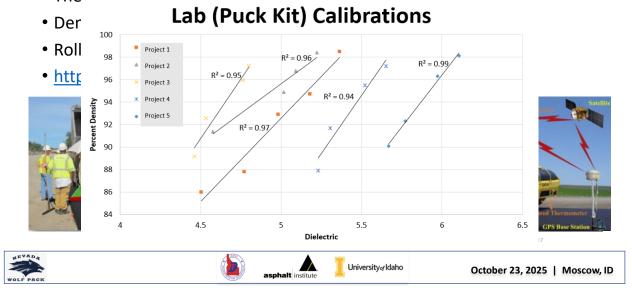






INTELLIGENT CONSTRUCTION TECHNOLOGIES (ICT)

• Thermal Profiling Manning



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INTELLIGENT COMPACTION



WOLF PACK

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INTELLIGENT CONSTRUCTION TECHNOLOGIES (ICT)

- Roller Pass Mapping
- Thermal Profiling
- Density Profile Mapping

WOA 2025 - A Closer Look: Hamm's New Smart Compact Pro



https://www.youtube.com/watch?v=2UTk8vz5bdk



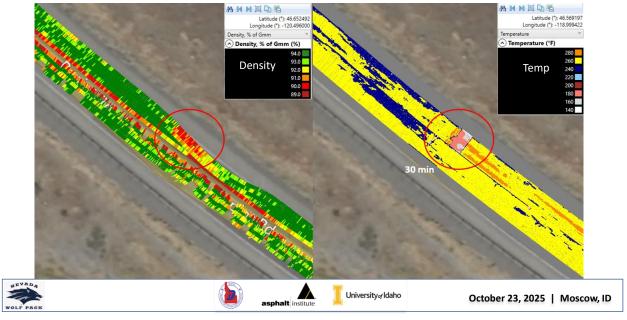
53

INTELLIGENT COMPACTION



WOLF PACK

INTELLIGENT COMPACTION



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ROLLER CHECKING / ROLLER MARKS



MAT BLISTERS





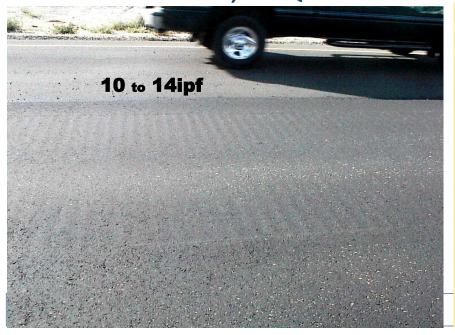




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IMPACTS PER FOOT, FREQUENCY & ROLLER SPEED



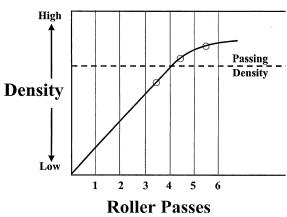
MAXIMUM ROLLING SPEED (MPH)								
SP	EED IN	MILES	PER HO	DUR				
	TO ACHIEVE DESIRED IMPACTS PER FOOT							
776	IMPACT	IMPACTS PER LINEAR FOOT (IPF)						
VPM	10	10 11 12 13 14						
1850	2.1	1.9	1.8	1.6	1.5			
2000	2.3	2.1	1.9	1.7	1.6			
2500	2.8	2.6	2.4	2.2	2.0			
2700	3.1	2.8	2.6	2.4	2.2			
3000	3.4	3.1	2.8	2.6	2.4			
3100	3.5	3.2	2.9	2.7	2.5			
3200	3.6	3.3	3.0	2.8	2.6			
3400	3.9	3.5	3.2	3.0	2.8			
3600	4.1	3.7	3.4	3.1	2.9			
3800	4.3	3.9	3.6	3.3	3.1			
4000	4.5	4.1	3.8	3.5	3.2			
3000 3100 3200 3400 3600 3800	3.4 3.5 3.6 3.9 4.1 4.3	3.1 3.2 3.3 3.5 3.7 3.9	2.8 2.9 3.0 3.2 3.4 3.6	2.6 2.7 2.8 3.0 3.1 3.3	2.4 2.5 2.6 2.8 2.9 3.1			

MAXIMUM ROLLING SPEED (FPM) SPEED IN FEET PER MINUTE

TO ACHIEVE DESIRED IMPACTS PER FOOT									
	IMPACTS PER LINEAR FOOT (IPF)								
VPM	10	11	12	13	14				
1850	185	168.2	154.2	142.3	132.1				
2000	200	181.8	166.7	153.8	142.9				
2500	250	227.3	208.3	192.3	178.6				
2700	270	245.5	225	207.7	192.9				
3000	300	272.7	250	230.8	214.3				
3100	310		258.3						
3200	320	290.9	266.7						
3400	340	309.1	283.3	261.5	242.9				
3600	360	327.3	300	276.9	257.1				
3800	380		316.7		271.4				
4000	400	363.6	333.3	307.7	285.7				

QC DENSITY TESTING (% COMPACTION)













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BROKEN AGGREGATES - SOFT LIMESTONE











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"TIME AVAILABLE" FOR COMPACTION

- "Time Available" length of time for HMA mix to cool from initial placement temperature to the cessation temperature (typically ≈170-175°F)
- Breakdown and Intermediate (Finish Rolling) Conducted within "Time Available"
- Primarily Defined By
 - Temperatures (Atmospheric, Initial HMA Mat, and Base)
 - Lift or Mat Thickness



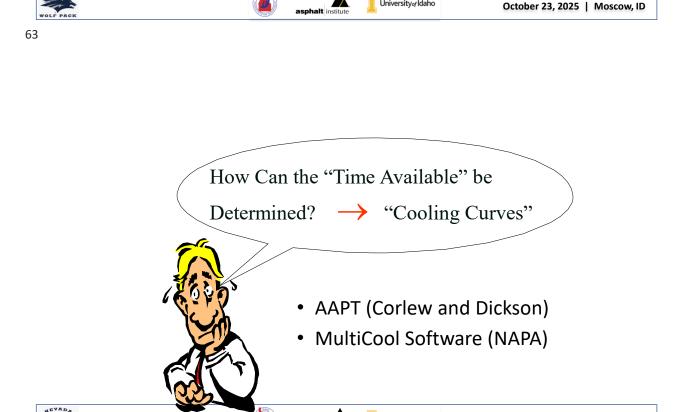






TIME AVAILABLE FOR COMPACTION

- Defines
 - Types of Rollers
 - Number of Rollers
 - Requires Balanced Operations
- May Require Changes from "Normal"
 - Plant Production
 - Laydown Speeds
 - Roller Types and Numbers

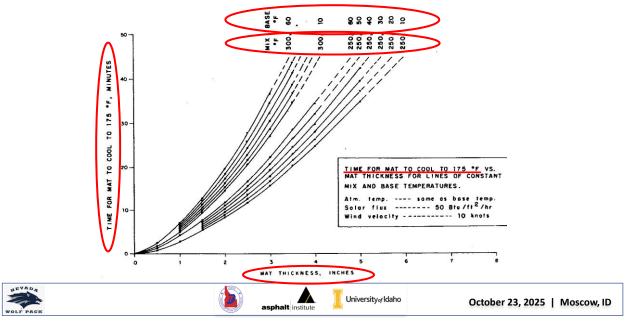


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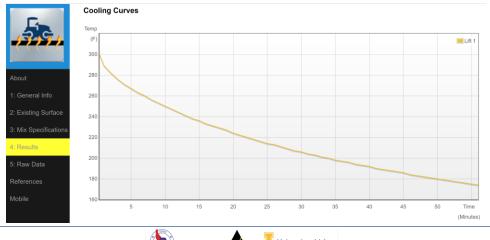
COOLING CURVE



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MULTICOOL SOFTWARE

• Free Download from NAPA Website



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LONGITUDINAL & TRANSVERSE JOINTS











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LONGITUDINAL JOINTS













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LONGITUDINAL JOINT - BUILD IT RIGHT



METHOD OF IMPROVING JOINT DENSITY

- Cut Joints
 - Saw Cut
 - Pizza Cutter
- Joint Heaters
- Joint Mastics











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SAW CUT LONGITUDINAL JOINT











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PIZZA CUTTER LONGITUDINAL JOINT











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BEST PRACTICE – NO TOUCH JOINTS











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SAME PAVING CREW – WHAT HAPPENED?











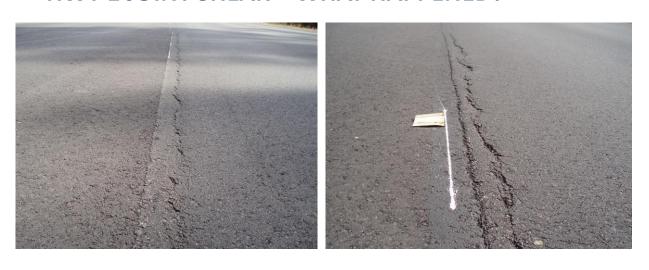
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SAME PAVING CREW – WHAT HAPPENED?



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HWY 1 JOINT SHEAR – WHAT HAPPENED?











JOINT HEATER

- Additional Equipment
- 5 Propane Heater Sections
- Paving Speed
 - 25fpm) ≈ 275tph
- All Techniques Effective
 - Good Joint Density
 - Saves \$ & Time









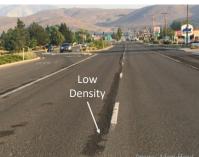


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JOINT LAYOUT, DENSITY, & COMPACTION















JOINT DENSITY TESTING



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SLIPPAGE FAILURES – TACK COAT



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SLIPPAGE FAILURES R&R SAME DAY - BINDER









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INSPECTION

- What is being inspected?
- Catch & Correct Fixable's ASAP • Eliminate Re-work
- What is being missed?
- Don't Be this Person!!!

	DATE	
Satisfactory	Less Thun Satisfacture	N/A
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		Mathematical Math













ARE YOU STILL AWAKE?







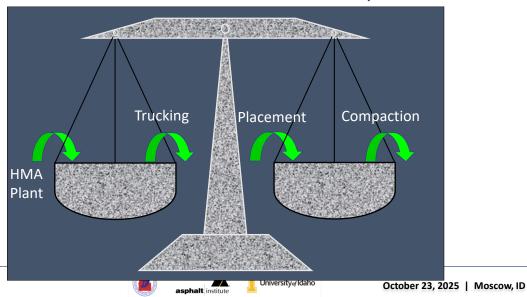




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BALANCING OPERATIONS = UNIFORM PRODUCTION = QUALITY = GOOD PERFORMANCE = JOBS = \$













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MATERIALS TRANSFER DEVICES











WINDROW ELEVATOR VERSUS MATERIAL TRANSFER VEHICLE (MTV)

MTVs

- smoothness, uniformity of temperature and reduced segregation One demonstration project compared density with MTV versus windrow elevator
- Density increased 2.6% with MTV vs. windrow elevator













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QUALITY CONTROL & ACCEPTANCE

6 Core Elements of a QA Program



Source: FHWA HIF-23-036

Most Common Production QC

- Binder
- Moisture
- Gradation top size
- Density
- Thickness
- Curing









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APRT IMPLEMENTATION WORKSHOP



SOW B.3.1

Team: Adam Hand (UNR), Jason Wielinski (Asphalt Institute)

- State agencies are at varying stages of implementing the Asphalt Pavement Recycling Technologies (APRT) in their programs.
- The APRT technologies include Hot In-place Recycling (HIR), Cold In-place Recycling (CIR), Cold Central Plant Recycling (CCPR) and Full Depth Reclamation (FDR)

Objective:

- Develop a workshop to provide State DOTs knowledge on how to get started and/or move forward with implementation of APRT technologies
 - Based on case studies, example specifications, review of existing standards, etc.
- Modular based so agencies can select which technologies they need information

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The **free workshops** will be delivered in-person or virtually using Microsoft Teams or any other meeting platform accepted by a State Department of Transportation (DOT).

DESCRIPTION

This federal Highway Administration (FHWA) workshop(s) will provide State DOTs with knowledge on how to get started and/or more forward with impermentation of asphalt pawment recycling technologies (APRT) based on indepth case studies from key State DOW, Workshops are customized to a State DOTs current situation with its APRT implementation program. APRT includes cold in-place recycling, cold central plant recycling, full depth reclamation with applial or center, and not be injective recycling.

- a. The overall APRT and their unique benefits.
- c. Positive practices and lessons learned by key State DOTs.

Workshops will focus on the APRT of interest to the DOT for implementation that were developed and conducted based on in-depth case studies of key State DOTs.

There are 4 APRT workshop modules, one for each APRT. Each APRT module is 2 hours. DOTs can select 1 or up to 4 APRT modules. The workshop can be delivered over the course of one or multiple days.

TARGET AUDIENCE

The successful implementation of APRT will need to be a team effort. Thus, the target audiences for the workshop are managers and practitioners interested in the implementation of APRT from State DOTs, industry, academia, and consultants. This involves participants from various offices of a State DOT, such as materials, pavement design, construction, and pavement management.

OUTCOMES

Upon completion of a workshop, participants will be

- · Understand the why and overall benefits of APRT(s).
- Recognize the planning and coordination effort associated with selection, design, construction and quality assurance for APRT.
- · Identify the tasks needed for effective development and implementation of APRT program(s).
- Recognize successful key State DOTs practices and experiences related to APRT.
- Recognize available external technical information and support with APRT.



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FOR MORE INFORMATION:

Contact Timothy Aschenbrener to timothy.aschenbrener⊕dot.gov



CIR/CCPR QUALITY ASSURANCE WORKSHOP



SOW B.3.2

Team: Jason Wielinski, Dave Johnson (Asphalt Institute), Adam Hand (UNR) Why:

- CIR/CCPR Technologies are like HMA, however construction and materials properties require different QA procedures and analysis.
- Agencies new to CIR/CCPR may not be familiar with these materials, specifications or processes Objective:
 - Develop a workshop that demonstrates quality assurance practices and procedures for agencies implementing CIR and CCPR in their programs
 - Workshop is targeted for 4-6 hours in length
 - Explains example specifications and standards related to CIR/CCPR

SOW B.3.3 is the deployment of the workshop

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THANK YOU!

- Adam Hand, PhD, PE_{IN, NV, NM, OR}
- Professor / Consultant
- UNR / Reno, Nevada
- (775) 742-6540
- adamhand@unr.edu















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Montana's Experience with SMA and HiMod: Demonstration and Discussion



Background Information



- Montana Mix Design History
 - Marshall
 - Primary design method for over 60 years
 - 50-blow and 75-blow designs
 - Superpave

2

- 2000 began transition
 - End-result
 - Volumetric
- 2007 volumetric acceptance on all Superpave projects
- By 2022 exclusively Superpave

Background Information



• Binder

3

- Penetration graded specification
 - 85-100
 - 120-150
- 1992 MSU Research into Modified Binders
- 1998 Adopted Modified Binders for all Interstate projects
- \circ ~2004 AASHTO M320 Performance Graded adopted
- ° 2024 AASHTO M332 MSCR adopted



Montana Pavement Performance



- Very Good Overall
 - Five Perpetual Pavement Awards
 - 20+ years of service common
- Localized Distresses

- ∘ Stripping → adopted lime requirement (1.4%)
- ∘ Rutting → adopted polymer modification
- Continuing to Look for Additional Performance Improvements

Looking at Options



- Stone Matix Asphalt (SMA)
 - ° Regionally used (Idaho, Colorado, Utah, New Mexico...)
 - $\,{}^{_{\odot}}$ Generally great performance reported
- HiMA
 - Kraton system
 - 7+ precent polymer
- HiMod
 - Utah pioneered system
 - Low air void design
 - ∘ ~5 percent polymer

SMA Option



- Gradations
 - MDT mixes generally gap-graded already
 - → early chipseals
 - Potential issues
 - Aggregate quality
 - Contractor experience
 - No experience in maintaining SMAs

HiMA Option



- "Proprietary" System
 - Kraton Polymer's developed modification system
 - ∘ 7% SBS polymer minimum
- No Montana Experience



HiMod Option



- No Montana Contractor Experience
- Montana Binder Suppliers
 - Suppliers lack familiarity
 - In the M320 system, 110 degree UTI (PG 76-34)
 - Balanced binder properties
 - Pumpability vs. Stiffness
 - M320 vs. M332

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HiMod Option



Gradations

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- Majority of MDT gradations are gap graded
 - HiMod begs for a fine gradation
 - Fine gradations are rare in Montana
- Portable operations
 - Sufficient angularity
 - Different pit management
 - Minus #4 materials
 - ∘ 35-40 percent passing typically
 - ∘ Utah 55-65 percent passing on HiMod

Montana Decision

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- Move forward with HiMod
- Initial project: North 19th in Bozeman



Montana Process – Emulate Utah's Specification



Utah's Specification

- HiMod binder
 - M320
 - PG76-34
 - Unaged DSR, AASHTO T 315 @ 76°C, G*, 1.3 kPa minimum
- 15% RAP (mass) allowed
- No natural fines
- ∘ 12.5 mm mix
- ∘ 50 gyrations
- ∘ 1% target air voids

- Montana's Specification
 - HiMod binder
 - M332
 - PG 64E-34
 - No unaged DSR requirement
 - 15% RAP (binder replacement) allowed
 - No natural fines
 - ∘ 9.5 mm mix
 - 50 gyrations
 - ∘ 1% target air voids

Montana Process – Emulate Utah's Specification



- Utah's Specification
 - Must pass the Hamburg
 - 20,000 passed
 - 158-pound load

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- 54°C bath temperature
- 10 mm max rut depth

- Montana's Specification
 - Must pass the Hamburg
 - 20,000 passed
 - 158-pound load
 - 50°C bath temperature
 - 12.5 mm max rut depth



Courtesy of Rutgers University

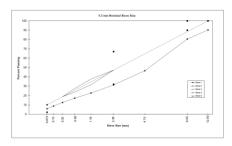
How did it go?



• Hamburg - FAILED

Unaged DSR, AASHTO T 315
 @ 76 °C, G*, 0.7 kPa (1.3 min)

- Gradation
- Very high binder content 7.5%
- Tried other 9.5 mixes



How did it go?



- Time is ticking!
- Change order called
 - Adopted UDOT specification without any alterations
 - HiMod binder
 - 。M320
 - o PG76-34
 - ∘ Unaged DSR, AASHTO T 315 @ 76°C, G*, 1.3 kPa minimum
 - 15% RAP (mass) allowed
 - No natural fines
 - 12.5 mm mix
 - 50 gyrations
 - 1% target air voids

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How did it go?

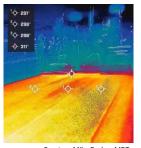


- Mixture was approved!
 - o PG 76-34
 - Rotational Viscometer, AASHTO T 316 @ 135°C, Pa.s 4.4 kPa
 - 6.4% binder (5.5% virgin)
 - 15% RAP (14.3% binder replacement)
 - $^{\circ}$ Passed Hamburg ~3.5 mm @ 20,000 passes

How did it go?



- Binder's viscosity created problems
 - Choked production to 170-250 ton/hour (400 ton/hour plant)
 - Dramatic increase in paving time
- Construction
 - Night paving
 - CAT SDX screed
 - Six roller passes
 - Consistent 97% density



Courtesy Mike Dodge, MDT

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Courtesy Mike Dodge, MDT

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itesy ivina bouge, ivibi



Results and the Future of HiMod in Montana

- Great densities
- Quality ride
- Two more projects getting bid in 2025
 - ∘ US Highway near Kalispell
 - Interstate in Missoula District
- Exploring additional projects

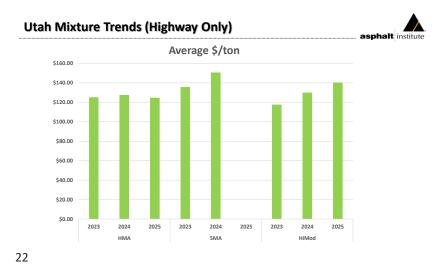


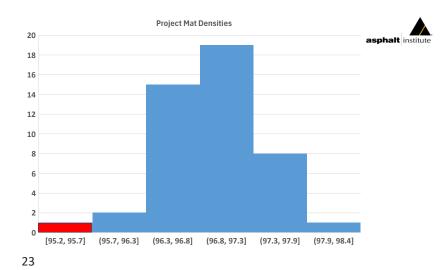
Back to the Mother Ship

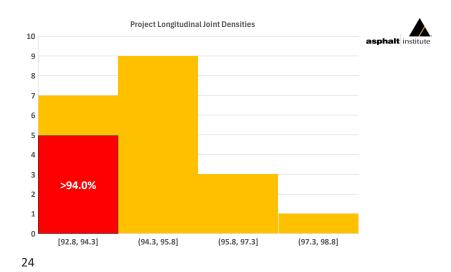
asphalt institute

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Utah Mixture Trends (Highway Only) asphalt institute Tonnage (As of Aug. 27) нма SMA HiMod







Lessons Learned

- Density of 96+% is common
- Regular rolling equipment and procedures followed
- Feeding while placing of a large volume of mix was achieved
- Mix is stable and workable
- Thin lift (1.5") projects are becoming common
- Bridge decks
- No distresses to date nor problematic installations
 Longitudinal joints (94%) on thinner lifts sometimes a challenge
- DOT and Utah Contractors love this mix

Some Notable Utah Facts



- 20-fold increase in usage in 2024 from all previous years combined
- 2025 90% of asphalt tonnage in Region 2 (SLC) HiMod
- The biggest advocate for more PCC is now flipping PCC projects
- Exceptional performance on all current installations
- 2024 Cost Data
 - HiMod 6.6% higher than Superpave (with a PG 64-34 binder)
 - SMA 27.0% higher than Superpave (with a PG 64-34 binder)

Thank-you AI Members!!



Questions?



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▶IDAHO

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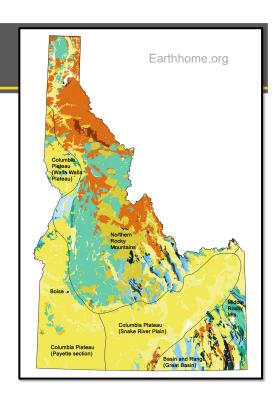
Balanced Mix Design: Validation in North Dakota

Zane Hartzog, P.E.
Assistant Research Engineer

1

Why use BMD?

- Every mix is different, every state is different
- Superpave mix design addresses rutting, but not cracking, thermal distress, or surface characteristics
- Better knowledge of each mix design's resistance to distresses
- Allows for innovation, more durable does not mean more expensive









With the current volumetric mix design system...









"Asphalt mix design framework using mechanical tests correlated to field performance on appropriately conditioned specimens that addresses multiple modes of asphalt layer distress taking into consideration mixture aging, traffic, climate, and location within the pavement structure."

- AASHTO PP 105-24



Balanced Mix Design BMD



Л

How is BMD Different?



- Current specifications rely on specifying <u>components</u> and the <u>proportioning</u> of the mixture.
 - 1.Aggregate
 - 2. Asphalt Binder
 - 3. Recycled Materials
 - 4.Others

BMD aims to evaluate the final product rather than the individual components and their proportioning!





5

What do cookies and asphalt have in common?









Validation vs. Benchmarking



How Validation is Different from Benchmarking?

Validation

- <u>Primary goal:</u> Make sure that the performance test results have a strong relationship to field performance.
- Critical for proper test selection and supporting the development of specification criteria.



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Why Validate?





Design Phase Test Results (Design Approval)



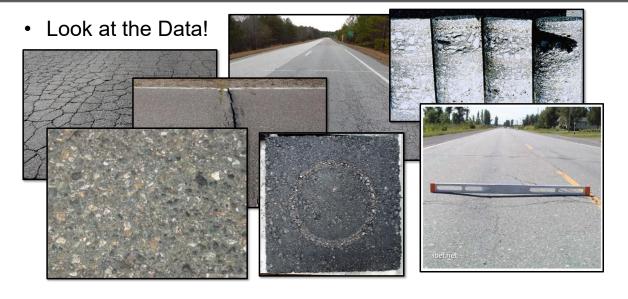
Construction Phase Test Results (QC/QA)



Use Phase Test Results (Pavement Management)

Before Validation





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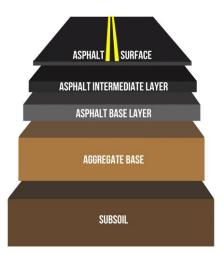
Validation Sections



- Label them
- Monitor them
- Appropriate length
 - 500 ft absolute minimum



Validation Sections



- Uniform subgrade
- Appropriate underlying pavement layers



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Validation Sections



- Consider:
 - RR Crossings
 - Bridges
 - Culverts
 - Intersections
 - Other load factors (industry)

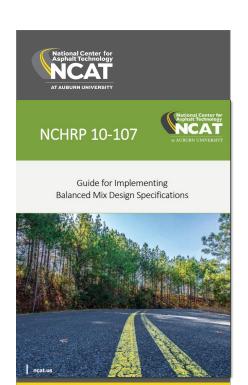
Validation Sections



- Avoid:
 - Excessive grades
 - Curves
 - Variable speeds



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Before Validation

- Establish Parentships
 - State DOT
 - Industry
 - Academic
 - FHWA



NDODT BMD Stakeholder Team



- Knife River Materials
- Mayo Construction
- Border States Paving
- Northern Improvement
- Sundre Sand & Gravel
- Terracon
- Aaron Swan Labs
- NDDOT
- DAPA
- NCAT
- FHWA



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NDODT BMD Stakeholder Team



- FHWA
 - TPF-5(478) DEMO TO ADVANCE NEW PAVEMENT TECH
 - \$250,000



About the project



- Why is this project different?
- Because North Dakota is different



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About the project



- Cold Winters
 - · Record low -60 F w/o wind chill
- Hot summers
 - · Record high 121 F
- Thermal cracking is the primary distress concern
- Cracks reflect through overlays in one year



About the project





CHALLENGE #1

- Portable asphalt plants
- Hard to change materials on the fly



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About the project





CHALLENGE #2

- Unknown Aggregate Source
- Crushing and mix design happen weeks before paving
- Not much time for multiple mix designs and testing



About the project

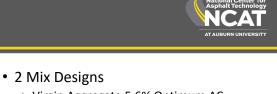




CHALLENGE #3

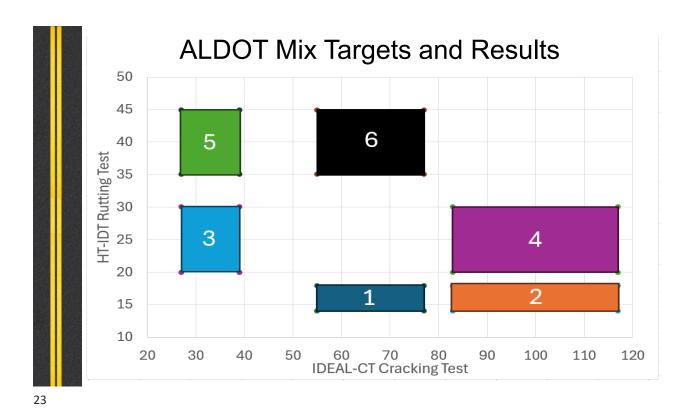
- Constructing a large project in a short season
- Pave from June thru October

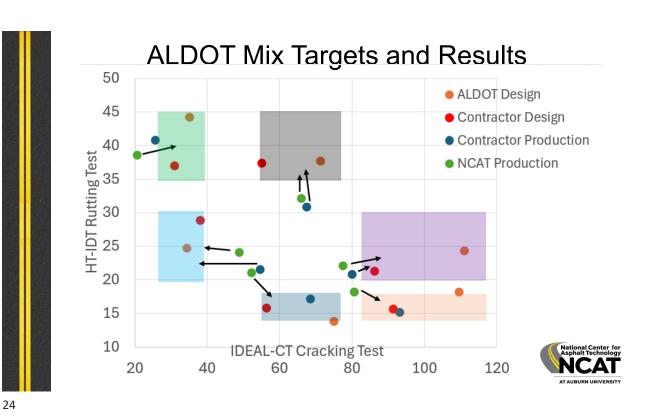






- - Virgin Aggregate 5.6% Optimum AC
 - RAP mix 4.7% AC + 0.93 = 5.63% AC
- Contractor provided 100 lbs. of each of the 8-test section mixes to NDDOT
 - Optimum 5.6
 - Optimum minus 5.1
 - Optimum plus 6.1
 - RAP 4.7 + 0.93 = 5.63
- Two AC Grades
 - 58S-28
 - 58H-34 polymer modified





Sampling



- Get all you need...
- then get some more
- Consider:
 - Which tests
 - · Which aging conditions
 - Re-runs
 - That someone may will think of something later
- 400 lb minimum

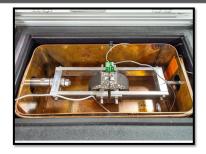


25

Tests and Results













IDEAL-CT



- "Quick" Cracking test
 - ASTM D8225
 - 25°C (77°F) for 2 hrs
 - · Indirect tension
 - Test set up like TSR
- CT-index accounts for
 - Fracture Energy
 - Post peak displacement
 - Post peak slope of stress strain curve



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IDEAL-CT



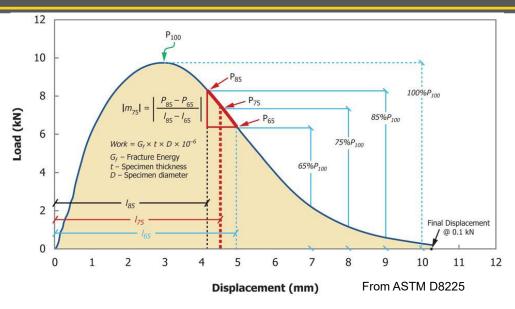


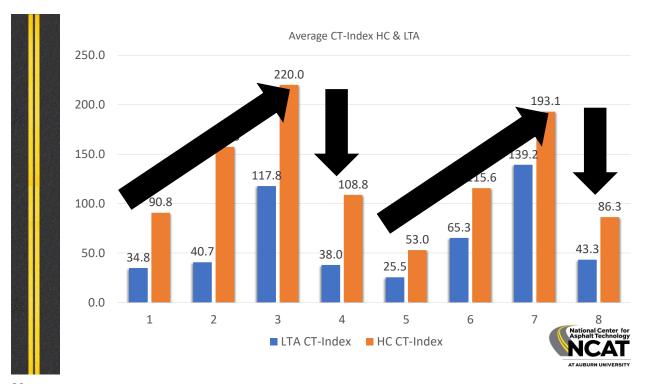




IDEAL-CT







IDEAL RT





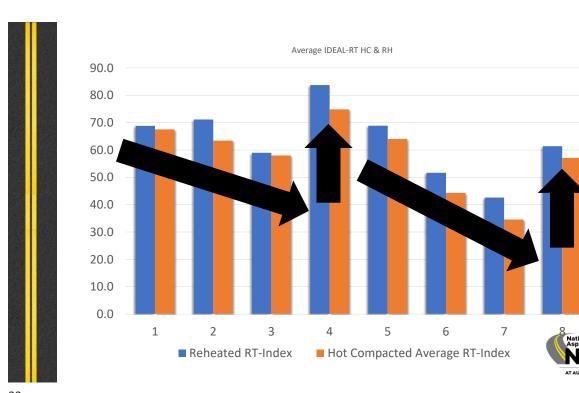
"Quick" Rutting Test

- ASTM D8360
- 46°C (115°F) for 1 hour
- Load applied similar to TSR, bottom supported in 2 places

RT-Index

· Depends only on peak load

31

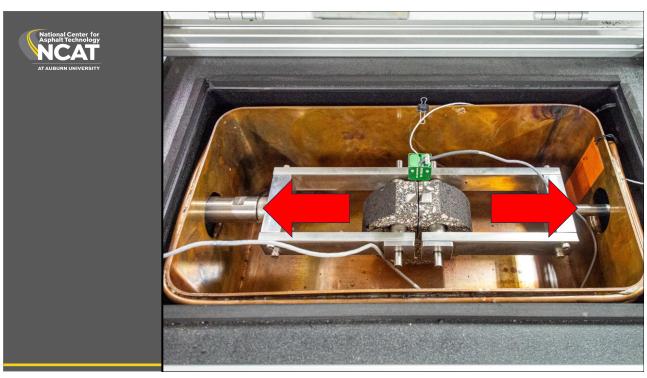


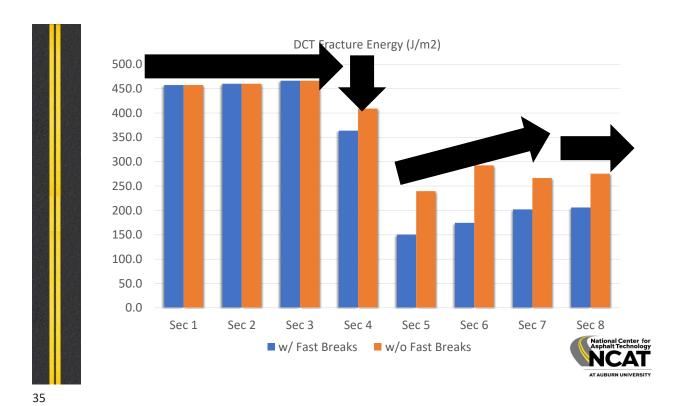
Disk-Shaped Compact Tension (DCT)



- Thermal Cracking tests
 - ASTM D7313
 - 2 hours at -24°C (-11°F)
 - Pulls sample apart to propagate crack
- Fracture energy (J/m²)





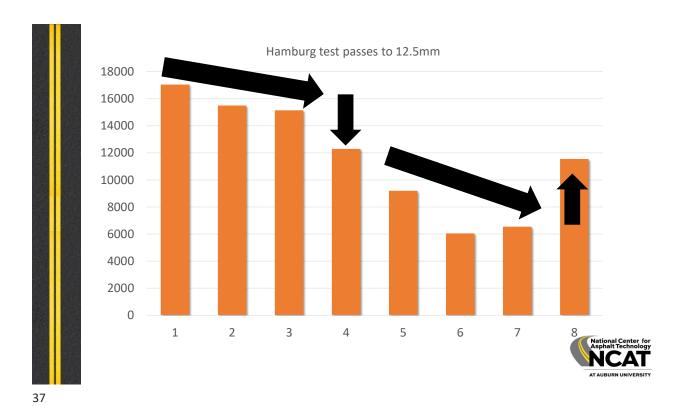


Hamburg Wheel Track Test (HWTT)





- Cyclic loading rutting test
 - Tests rutting, stripping, and agg breakdown
 - Performed in 46°C (115°F) water
- Rut depth in mm at x passes
- · Passes to failure



Headlines from the Alabama Field Validation Study 0.20 LMLC (ALDOT) Linear (LMLC (ALDOT)) y = -0.0024x + 0.1536 R² = 0.9262 0.00 HT-ITS (psi)



- We understand why we are moving to BMD
- We know the difference between validation and benchmarking
- We know there are lots useful resource to help
- We know North Dakota has Buffalo and BMD Validation Sections
- We know Alabama has awesome BBQ and BMD Validation Sections







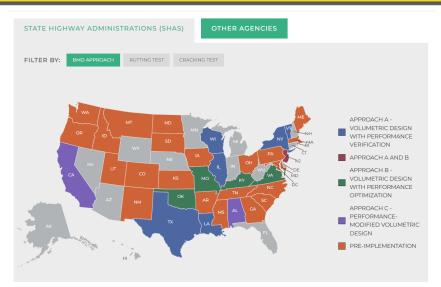


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Resources









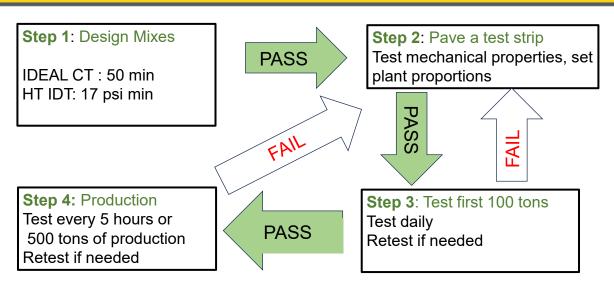




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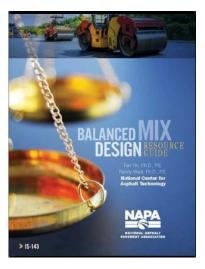
Resources: Alabama County BMD









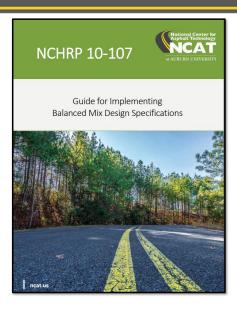


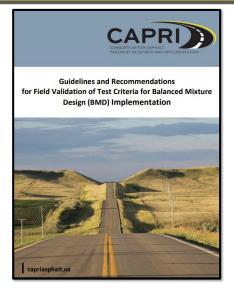


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Resources













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Resources





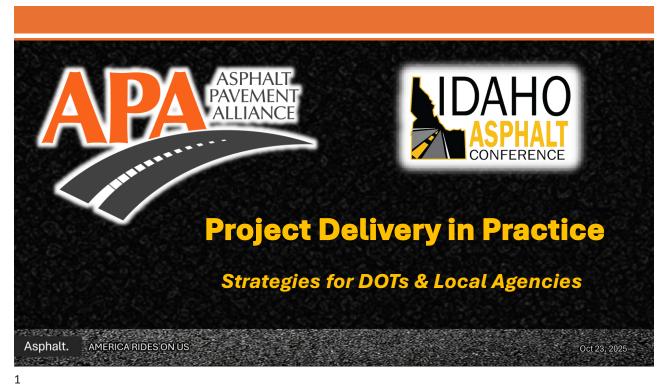


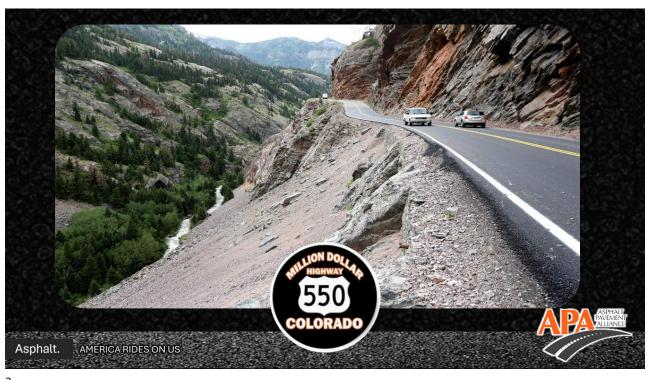
NCAT Balanced Mix Design Course March 31 – April 2 2026

- Overview of balanced mix design
- · Pavement distresses and critical layers
- Discussion of test equipment options
- Testing for rutting resistance
- Testing for crack resistance
- · Testing for moisture susceptibility
- Balanced mix design approaches

For more Information Stacie Hunter slh0037@auburn.edu

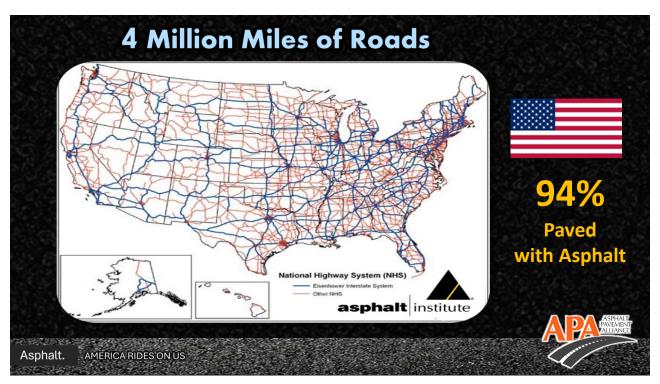














Perpetual



7

Trends



Funding Trends



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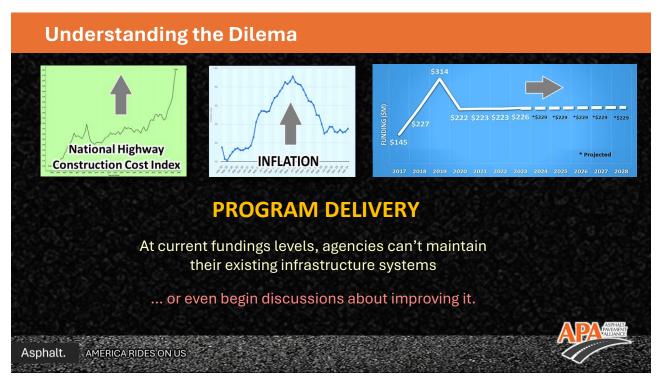


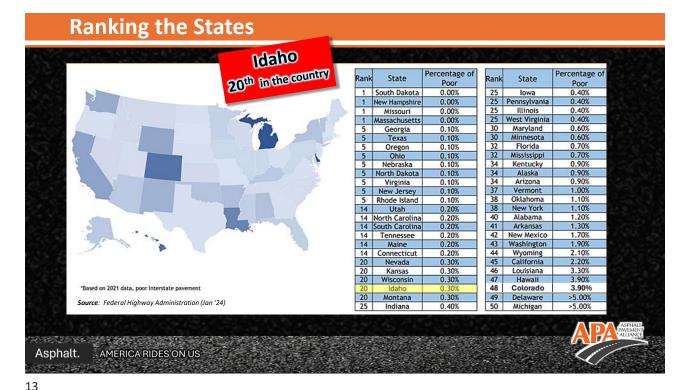


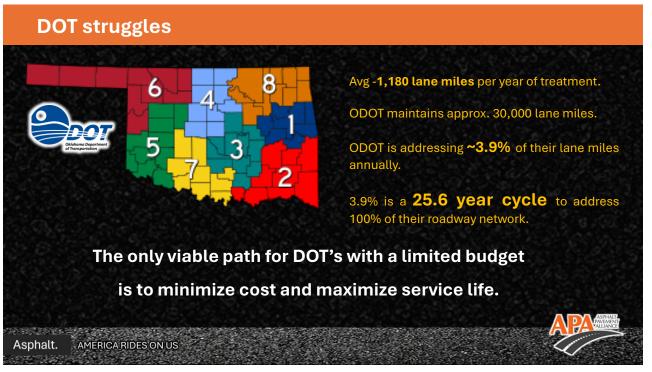
Technical Trends

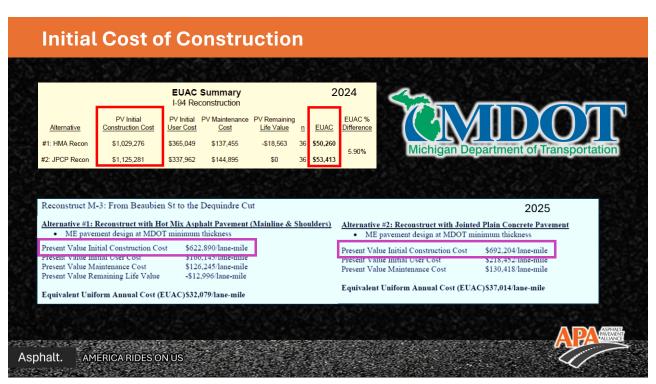


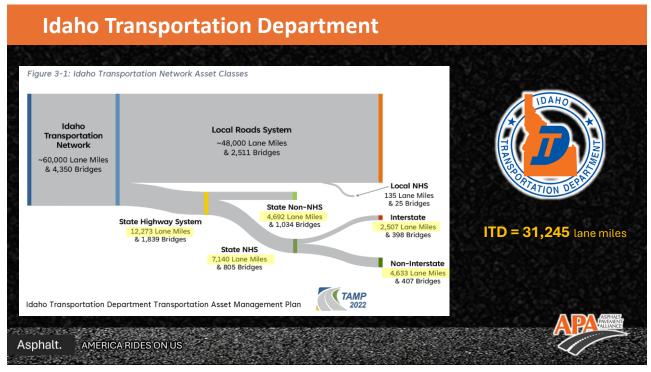
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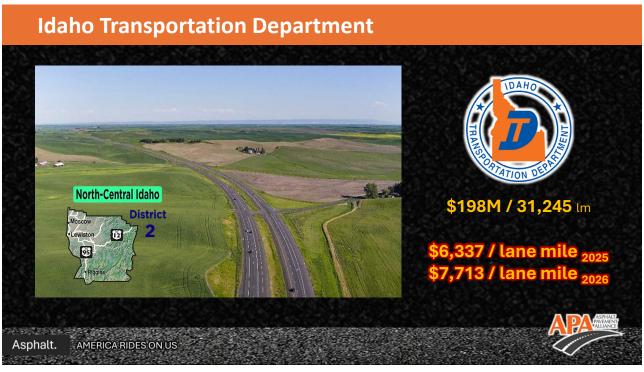








able 7-6: Funds Programed for A FY 2022 - 2031 Proposed ITD Te ITD Funding & Use Summary (\$	n-Year Tra	nsportation	Plan	oacity Projec		ansportation	Department T	ransportation	Asset Manaç	gement Plan	TAMP 2022
Funding for Transportation	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028	FY2029	FY2030	FY2031	10 Yr Total
Pavement Funding	313	152	200	198	241	228	171	145	145	145	1,938
Bridge Funding	80	80	100	100	100	100	100	100	100	100	960
Supporting Infrastructure Assets	7	7	15	15	15	15	15	15	15	15	132
Safety & Capacity	60	60	60	60	60	60	60	60	60	60	600
Freight (x 30% for SHS)	3	3	3	3	3	3	3	3	3	3	34
Carbon (x 100% for SHS)	3	3	4	4	4	4	4	4	4	4	36
Protect	11	11	12	12	12	12	12	12	12	12	118
System Support	7	7	7	7	7	7	7	7	7	7	65
Board Unallocated	10	10	10	10	10	10	10	10	10	10	100
TECM		215									215
Funding for Transportation	\$494	\$548	\$410	\$408	\$452	\$438	\$381	\$355	\$355	\$355	\$4,197



State Funding Struggles

INDOT Anticipated Funding Levels by Funding Category, 2018-2045, in Future Year Dollars **CURRENT STIP PROJECTION YEARS** STIPFUNDING CATEGORY FY 2019 FY 2018 FY 2020 FY 2021 FY 2022 FY 2023 FY 2024 FY2025-2045* StateFederal-aid FHWA funds \$786,700,000 \$799,300,000 \$813,500,000 \$808,300,000 \$808,300,000 \$808,300,000 \$808,300,000 \$808,300,000 EarmarksState \$800,000 \$169,281 \$0 \$0 \$242,320 \$242,320 \$242,320 \$242,320 LocalFederal-aid FHWA funds \$246,900,000 \$252,500,000 \$276,633,333 \$252,500,000 \$252,500,000 \$252,500,000 \$252,500,000 \$252,500,000 \$10,788,764 \$7,557 \$0 \$0 \$0 **FHWAEarmarks** \$1,862,263 \$2,205,934 \$0 Subtotal of Federal-aidFHWA \$1,045,188,764 \$1,053,831,544 funds =\$1,092,339,267 \$1,060,807,557 \$1,061,042,320 \$1,061,042,320 \$1,061,042,320 \$1,061,042,320 Subtotal of Federal-aidFTA funds = \$22,750,000 \$22,750,000 \$22,750,000 \$22,750,000 \$22,750,000 \$22,750,000 \$22,750,000 \$22,750,000

IDOT: Long Range Transportation Plan 2018 - 2045

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Funding Metrics

\$241,000,000 / 31,245 = **\$7,300** per lane mile



\$252,500,000 / 28,421 = **\$8,884** per lane mile



\$255,000,000 / 23,000 = **\$11,086** per lane mile



\$1,500,000,000 / 46,000 = **\$32,608** per lane mile

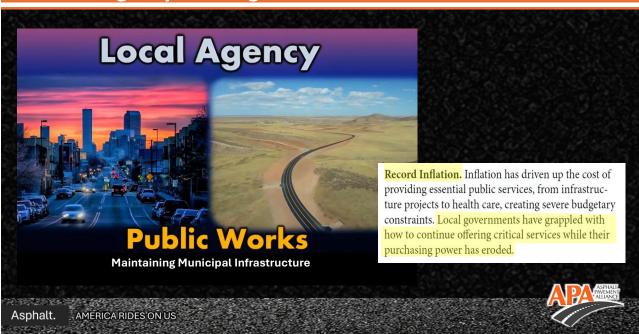


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Local Agency Funding



21

Funding Trends

Local Agency	Paved Lane Miles	Year	Annual A Progr		PCI	
			Mill/Overlay + Preventive + Crack Seal			Colorado Asphalt
El Paso County	2368	2024	\$22,000,000	\$9,291	68	Pavement Association
Englewood	339	2024	\$7,000,000	\$20,649	64	Pavement Condition
Erie	321	2024	\$3,742,900	\$11,660	80	Funding and Performance
Estes Park	114	2025	\$1,530,000	\$13,421	81	Colorado colorado Local Ager
Evans	191	2024	\$600,000	\$3,141	68	INCLUDES DATA FOR OVER 100+ LOCAL AC
Federal Heights	39	2024	\$1,650,000	\$42,308	75	The first transport to the state of the stat
Fort Morgan	104	2020	\$3,200,000	\$30,769	60	tes testing the testing to the testing testing to the testing
Fountain	226	2024	\$800,000	\$3,540	31	Toronto John State of Control by State of Cont
Frederick	221	2023	\$1,750,000	\$7,919	79	Colorado Meneros Company Compa
Fruita	129	2022	\$250,000	\$1,938	70	
Ft. Collins	1994	2025	\$13,700,000	\$6,871	73	
Garfield County	716	2019	\$3,644,270	\$5,090		Colorado Data
Glenwood Springs	88	2023	\$805,000	\$9,148	35	
Golden	159	2020	\$1,800,000	\$11,321	84	
					763	<u> </u>
MERICA RIDES ON						





Local Agency Best Practice

Flexibility in Program Delivery

"Our annual Mill & Overlay Program is on a rollover contract. We maintain flexibility of our Streets Program by **adjusting the scope of work (tonnage)** as necessary if costs exceed contract values."

- Jeff Dankenbring (Public Works Director, City of Centennial)



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Local Agency Best Practice

Key Takeaways for Public Works Agencies:



- Send clear and regular messages to your stakeholders about your business operations status
- Make paying invoices on time a priority
- Keep projects moving in both design and construction
 - Decision-makers need to be part of remote meetings or respond promptly through email so that projects do not stall
- Initiate as many projects as possible to have in a queue so that we do not lose a construction season
 - Flexibility to start projects when needed to avoid consultants and contractors from being idle

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25

Project (Failed) Delivery

APWA survey found that over 50% of public projects are completed late and over budget



- Inflation
- Market Conditions: Supply/Demand, health care, workforce
- **Subcontractors:** Short Supply, including DBE subs
- Contract Requirements: Permitting, Environmental

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Asphalt Specifications: Design Gyrations



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Asphalt Mix Selection

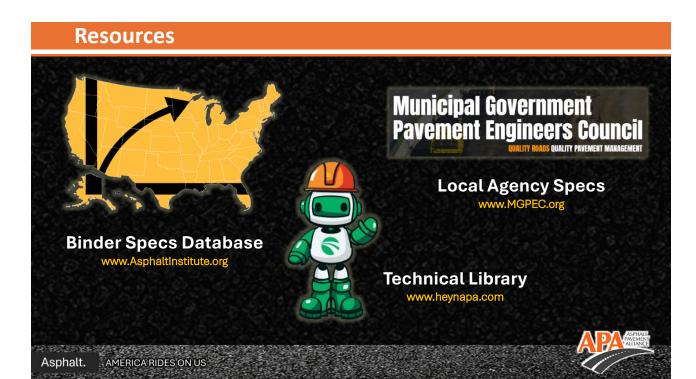


Asphalt Mix Selection



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Asphalt Mix Selection 4% Air Voids Asphalt. AMERICARIDES ONUS



www.DriveAsphalt.com







Optimizing the Paving Operation: From Production to Field Compaction

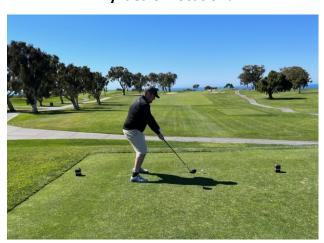
Dave Johnson, P.E.
Senior Regional Engineer
Rocky Mountain Region
Billings Montana

1

Any golfers or golf fans here?



Any idea on location?



What is the significance with the number 54?

- 54 is the score a player would achieve if a birdie was recorded on every hole on a par-72 course
- Would you consider this a perfect round?
- Any other ideas?
 - LIV golf get its name from the number
 54; roman numeral for 54
 - They play 54 holes on LIV events
 - 54 players

Has 54 ever been scored in professional round?



Best recorded round: Jim Furyk, 58, August 7, 2016
Travelers Championship, Final Round



3

Baseball fans: Remember him?





Diamondbacks pitcher Randy Johnson killed a bird with a pitch on March 24, 2001. *Michael Chow/azcentral* Sports

- What feat did Randy accomplish on May 18, 2004?
- Threw a perfect game against the Atlanta Braves.

		1	2	3	4	5	6	7	8	9	R	Н	E
DILLHOOD	Arizona Diamondbacks	0	1	0	0	0	0	1	0	0	2	8	0
Brank	Atlanta Braves	0	0	0	0	0	0	0	0	0	0	0	3
	WP: Randy Johnson (4-4) ◆ LP: Mike Hampton (0-5)												

- 27 batters, 27 outs, no hits, no walks, no baserunners, no runs
- Aspirational goal for a pitcher and team
 - Objective that challenges the limits of what's possible

What does "perfect" paving day look like?





- Thoughts?
 - Production Targets
 - Efficiency
 - Quality
 - Smoothness
 - Density
 - Safety
- Aspirational goal for paving?
 - Paver runs at a constant speed throughout the shift
 - ∘ 100% efficiency

5

Always start with "Why?"





Featured in Life Magazine, 1957





Aspirational Goals



- How many contribute to Jim's near-perfect 58 score?
 - 1? (Jim), maybe his caddy/coach
- How many contribute to Randy's perfect game?
 - 9, Randy plus his 8 fielders on defense
- How many are involved in your perfect paving day?









7

Balancing the Paving Operation





The synchronized balance of the four phases of asphalt paving to provide continuous paving operations.

Foreword



- We will discuss some fundamental concepts around the balanced paving operation
- More detail and examples are provided in MS-22
- Classes available provide a deeper dive into balanced operations
 - Asphalt Institute CQAP
 - Asphalt Institute PIC (online)

Course Outline

- Module 1: Inspector's Authority and Responsibility
- Module 2: Materials
- · Module 3: Mixtures and Mix Design
- Module 4: Plants & Production
- · Module 5: Transportation, Delivery, & Preparation
- Module 6: Placement
- Module 7: Compaction
- Module 8: Acceptance and Testing
- Each module roughly 90-120 mins
 Modules consist of ppt slides with audio, exam

http://www.asphaltinstitute.org/training/seminars/paving-inspectorcertification-nic/







9

Production



The basic operations of the HMA plant:

- 1. Proper storage and handling of the component materials
- 2.Accurate proportioning and feeding of the cold aggregate into the dryer
- 3. Effective drying and heating of the aggregate to the proper temperature
- 4.Efficient control and collection of the dust from the dryer
- 5. Proper proportioning and mixing of binder with aggregate
- 6. Proper storing, dispensing, and weighing of finished mix



Factors Impacting Production Rates



- Overall Plant Capacity and Size
- Silo Storage
 - Fully Heated & Insulated
 - Several Hundred Ton Capacity
- Daily Demand
 - How many mixes produced?
- Aggregate Moisture Content
 - Bigger Issue for Smaller Plants
- Discharge Temperature
 - Do Not Exceed Manufacture's Recommendations









11

Impact of Production Rate: Example



Jim's Crew

- Jim's crew is set up to pave
- Rained the night before
- Plant needs to produce multiple mixes
- Plant operator says 190 tons/hour doable
- How many tons can Jim expect today on his 8-hour shift?
- 190 tph * 8 hours = 1,520 tons

Randy's Crew

- Randy's crew is set to pave
- Plant is up and running and normal capacity
- Plant started early and place some mix in silo
- Plant operator says 290 tons/hour is doable
- How many tons can Randy get today?
- 290 tph * 8 hours = 2,320 tons

Balancing the Paving Operation





The synchronized balance of the four phases of asphalt paving to provide continuous paving operations.

13

The Hauling Operation



The hauling operation must provide a steady and consistent flow of asphalt mixture from the plant to the paver.

This is accomplished by:

- Timely and proper loading of trucks at plant
- Adequate number of trucks to support continuous paver speed throughout production
- Consistent use of proper techniques for loading and unloading trucks
- Consistent spacing of trucks
- Making sure delivered mix meets temperature and segregation requirements

The Contractor must anticipate the trucker's activities to properly estimate cycle time.



Types of Trucks

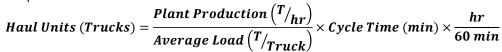


Truck Type	Capacity	Features	Example
End Dump	13 – 15 Tons	Lower capacity More maneuverable Good in tight spaces Overhead obstructions	
Semi-Trailer High Dump	20 - 22 Tons	Larger Capacity Easier to segregate Overhead obstructions	
Flow Boy Semi "Live Bottom"	20 – 22 Tons	Large Capacity No issues with overhead obstructions Regulated flow dump into hopper	AP-1055D

Verifying the Number of Required Trucks



- Critical to have adequate number of trucks to support plant production and established paving/rolling speed
 - Not enough trucks
 - Paving interruptions stop and wait
 - Too many trucks
 - · Waiting at the plant or paver
- · Inputs needed
 - Plant Production (tons/hour)
 - Average Load (tons/truck)
 - Cycle time (minutes)
 - · Includes spraying, loading, ticket, haul time, time to unload, clean-out, return time to plant



ARNE'S

Example Calculation



- Contractor will be producing at 340 tons/hour. They will be using semi trucks with high dump trailers hauling 22 tons of mix in each truck. Estimated cycle time is 30 minutes.
- Do we think ten trucks would be enough?
- What is the minimum acceptable number of trucks?

•
$$Trucks = \frac{340 \, \binom{tons}{hour}}{22 \binom{tons}{truck}} \times 30 \, (min) \times \frac{hour}{60 \, min}$$

$$Trucks = 7.7 \rightarrow 8 \, minimum$$

17

Comparing Hauling Requirements: Example



Parameter	Jim's Crew	Randy's Crew
Plant Production Rate	190 tons per hour	290 tons per hour
Average Truck Capacity	20 tons	20 tons
Cycle Time (Case 1)	45 minutes	30 minutes
Trucks Required (Case 1)		
Cycle Time (Case 2)	60 minutes	45 minutes
Trucks Required (Case 2)		

$$Trucks = \frac{\left(\frac{tons}{hour}\right)}{\left(\frac{tons}{truck}\right)} \times cycle\ time\ (min) \times \frac{hour}{60\ min}$$

- Who will need more trucks in Case 1?
- How many more trucks will be needed if cycle time increases 15 minutes (Case 2)?
- What should we do if we cannot get more trucks?

Trucks Available - Calculate the maximum production rate*



No. of Trucks Available	Max. Production Rate at 30-minute cycle time	Max. Production Rate at 45-minute cycle time	Max. Production Rate at 60-minute cycle time
4	160 tons per hour	106 tons per hour	80 tons per hour
5	200 tons per hour	133 tons per hour	100 tons per hour
6	240 tons per hour	160 tons per hour	120 tons per hour
7	280 tons per hour	186 tons per hour	140 tons per hour
8	320 tons per hour	213 tons per hour	160 tons per hour

$$Plant \ production \ rate = \frac{(No. of \ trucks \ available)x^{tons}/_{truck}}{cycle \ time \ (min) \times \frac{hour}{60 \ min}}$$

* Changes with average tons per truck (20 in this example) and truck cycle time. CANNOT provide more tons per hour than can be placed and compacted.

19

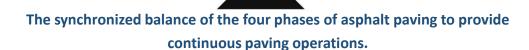
Balancing the Paving Operation







BALANCING THE PAVING OPERATION

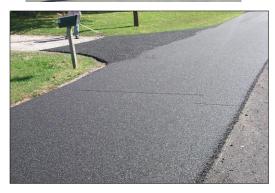


Paving



- What was our paving aspirational goal?
 - Paver runs at a constant speed throughout the shift
 - ∘ 100% efficiency
- What happens when we slow down or speed up?
- Or when we stop and start the paver?





21

"Free Floating" Screed



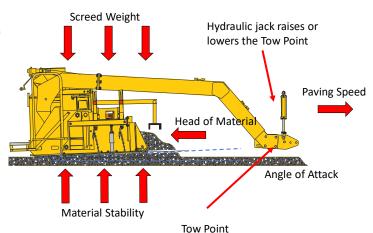


• The free floating screed finds equilibrium to run parallel to an imaginary line through the tow points known as the "Line of Pull"

Factors Affecting the Screed



- · Five factors affecting the screed
- 1. Screed weight (Downward force)
- 2. Mix Stability (Upward force)
- 3. Forward Motion (Horizontal Force)
- 4. Head of Material (Opposite horizontal force)
- 5. Angle of attack of the screed (Upward force)

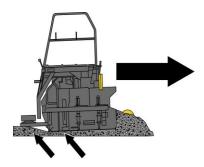


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Paving Speed

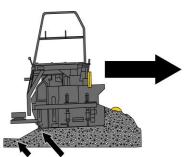


Increasing Speed



- Shear force decreases
- Depth decreases

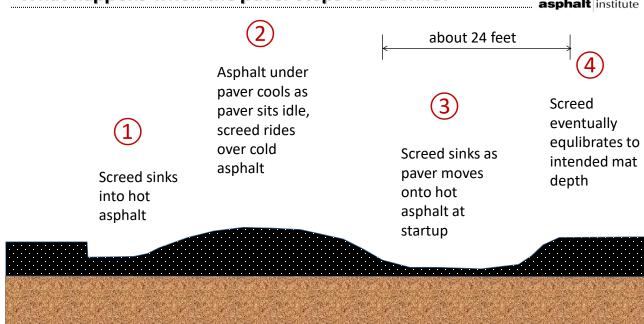
Decreasing Speed



- Shear force increases
- Depth increases

What happens when the paver stops for a while?





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Example: Paver Speed Based on Mix Delivery



Input	Jim's Crew	Randy's Crew
Plant Production (tons per hour)	190	290
Unit Weight of Mix (lbs./ cu. ft)	146.6	146.6
Compacted Lift Thickness (in.)	2.0	1.5
Width of Pull (ft)	12	14
Spread Rate (lbs. / sq. yd – in)	110.0	110.0

- Step 1: Determine the Spread Rate in $\frac{lb}{yd^2/in}$;
 - Expressed in pounds per square yard of HMA for every inch of compacted thickness
 - Based on the unit weight information provided by the QC lab.
- · Who will have the greater spread rate?

 $Spread\ Rate\left(\frac{lb}{yd^{2}/_{in}}\right) = Unit\ Weight\left(\frac{lbs}{ft^{3}}\right) \times \frac{1\ ft}{12\ in} \times \frac{9\ ft^{2}}{yd^{2}}$ $Spread\ Rate\left(\frac{lb}{yd^{2}/_{in}}\right) = 146.6\left(\frac{lbs}{ft^{3}}\right) \times \frac{ft}{12\ in} \times \frac{9\ ft^{2}}{yd^{2}} = 110.0$

Unit weight = $G_{mm} \times 62.4 \times target$ roadway density $2.500 \times 62.4 \times 0.94 =$

146.6 lbs./cu. ft.

Example: Paver Speed Based on Mix Delivery



Input	Jim's Crew	Randy's Crew
Plant Production (tons per hour)	190	290
Unit Weight of Mix (lbs./ cu. ft)	146.6	146.6
Compacted Lift Thickness (in.)	2.0	1.5
Width of Pull (ft)	12	14
Spread Rate (lbs. / sq. yd – in)	110.0	110.0
Paver Distance Covered in 1 Hour	1296	2260

• Step 2: Determine how far the paver will go in one hour at stated production rate

Production
$$\left(\frac{tons}{hr}\right)$$
Width $(ft)x$ Thickness $(in.)x$ Spread rate $\left(\frac{lbs.}{yd^2/lin}\right)$ x (Units Conversion Factors) = $\frac{feet}{hour}$

$$\frac{190 \left(\frac{tons}{hr}\right)}{12 \left(ft\right)x \ 2.0 \ (in.)x \ 110.0 \left(\frac{lbs.}{yd^2/lin}\right)} \times \left(\frac{2000 \ lbs.}{1 \ ton} \ x \ \frac{9 \ ft^2}{1 \ yd^2}\right) = 1296 \frac{feet}{hour}$$

Randy's Crew
$$\frac{290 \left(\frac{tons}{hr}\right)}{14 \ (ft)x \ 1.5 \ (in.)x \ 110.0 \left(\frac{lbs.}{yd^2/lin}\right)} \times \left(\frac{2000 \ lbs.}{1 \ ton} \ x \ \frac{9 \ ft^2}{1 \ yd^2}\right) = 2260 \frac{feet}{hour}$$

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Example: Paver Speed Based on Mix Delivery



Input	Jim's Crew	Randy's Crew
Plant Production (tons per hour)	190	290
Unit Weight of Mix (lbs./ cu. ft)	146.6	146.6
Compacted Lift Thickness (in.)	2.0	1.5
Width of Pull (ft)	12	14
Spread Rate (lbs. / sq. yd – in)	110.0	110.0
Paver Distance Covered in 1 Hour	1296	2260

• Step 3: Determine Paver Speed in feet per minute

Jim's Crew

Randy's Crew

$$\frac{Distance\ Covered\ in\ an\ Hour}{60\ \frac{min}{hr}} = Paver\ Speed\ \frac{ft}{min} \qquad \frac{1296\ \frac{ft}{hr}}{60\ \frac{min}{hr}} = 21.6\frac{ft}{min} \qquad \frac{2260\ \frac{ft}{hr}}{60\ \frac{min}{hr}} = 37.7\frac{ft}{min}$$

- This results reflect a scenario where the paver is not stopping at all
- 100% efficiency
- Can rollers keep up with correct number of passes at correct speed?

Example: Paver Speed Based on Mix Delivery



Input	Jim's Crew	Randy's Crew
Plant Production (tons per hour)	190	290
Unit Weight of Mix (lbs./ cu. ft)	146.6	146.6
Compacted Lift Thickness (in.)	2.0	1.5
Width of Pull (ft)	12	14
Spread Rate (lbs. / sq. yd – in)	110.0	110.0
Paver Distance Overed in 1 Hour	1296	2260
Paver Speed (ft/min) at 100% Eff	21.6	37.7

• Step 4 : Apply Efficiency Factor (Assume what portion of the time the paving will be moving)

Jim's Crew

Randy's Crew

• Let's assume the paver is running 90% of the time

$$\frac{21.6 \frac{ft}{hr}}{0.90} = 24.0 \frac{ft}{min}$$

$$\frac{21.6 \frac{ft}{hr}}{0.90} = 24.0 \frac{ft}{min} \qquad \frac{37.7 \frac{ft}{hr}}{0.90} = 41.9 \frac{ft}{min}$$

• What if the paver is running 80% of the time

$$\frac{21.6 \frac{ft}{hr}}{0.80} = 27.0 \frac{ft}{min}$$

$$\frac{21.6 \frac{ft}{hr}}{0.80} = 27.0 \frac{ft}{min} \qquad \frac{37.7 \frac{ft}{hr}}{0.80} = 47.1 \frac{ft}{min}$$

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Example: Paver Speed Based on Mix Delivery



Input	Jim's Crew	Randy's Crew
Plant Production (tons per hour)	190	290
Unit Weight of Mix (lbs./ cu. ft)	146.6	146.6
Compacted Lift Thickness (in.)	2.0	1.5
Width of Pull (ft)	12	14
Spread Rate (lbs. / sq. yd – in)	110.0	110.0
Paver Distance Overed in 1 Hour	1296	2260
Paver Speed (ft/min) at 100% Eff.	21.6	37.7
Paver Speed (ft/min) at 90% Eff.	24.0	41.9
Paver Speed (ft/min) at 80% Eff.	27.0	47.1

- · What big takeaways do we have from this exercise?
- Are these the target paver speeds that Jim and Randy need for the project?



The synchronized balance of the four phases of asphalt paving to provide continuous paving operations.

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Compaction Operations



Achieving density is a quality indicator

- If density is inadequate
 - · Increased voids and reduced pavement life
 - · Reduction in pay
 - · Remove and replace

This is accomplished by ensuring:

- Compaction is completed in the optimum temperature range
 - · Impacted by
 - Mix type, binder grade and project conditions
- Adequate number and type of rollers used to keep up with paver
 - · Within individual roller's recommended speed range
- Establishing project specific roller patterns
 - Determined by test strip density at beginning of project
- Best practices for mat and joint compaction should be used consistently throughout project



Factors Affecting Compaction



- There are five major factors that impact compaction:
 - Mat temperature
 - Mixture properties and characteristics
 - Layer Thickness
 - Environmental Conditions
 - Subgrade and Base







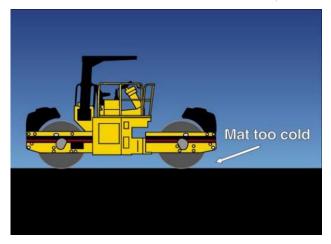


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Effect of Temperature - Mat Too Cold



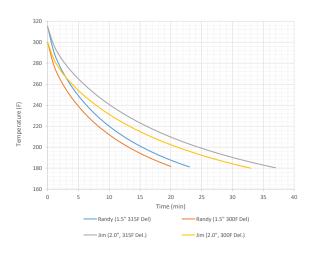
- Cessation temperature is
 - the minimum mat temperature where it can be reasonably expected that compactive effort will not substantially increase density
- Typically, 175-180°F
- Compacting below cessation temperature will result in:
 - No increase in mat density
 - Damage to the mat (breaking aggregate, etc.)
- Agencies commonly specify minimum mat temperature where compaction rolling must cease



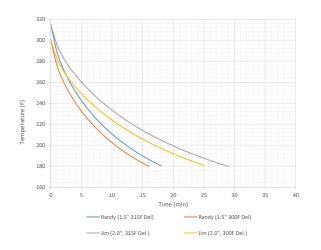
Impact of Project Conditions on Compaction Time



Let's Assume Ambient and Surface Conditions are 85°F



What if Ambient and Surface Temperature is 65°F?

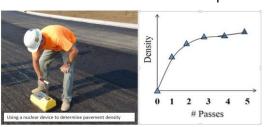


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Compaction Process – Important Considerations



- Best practices for compaction operation should be followed in these areas:
 - Determining roller requirements
 - The construction of a test section prior to paving is recommended
 - Number and types of rollers to be used in each phase of compaction
 - Roller passes for each roller
 - Roller speed
 - Time available for compaction based on mat temperature





Calculate Paver Speed Based on Compaction



Input	Jim's Crew	Randy's Crew
Plant Production (tons per hour)	190	290
Unit Weight of Mix (lbs./ cu. ft)	146.6	146.6
Compacted Lift Thickness (in.)	2.0	1.5
Width of Pull (ft)	12	14
Paver Speed – Plant (ft/min) at 90% Eff.	24.0	41.9
Passes for Coverage	2	3

- Step 1: Effective Roller Speed
- Assume effective roller speed of 3.7 ft./sec (2.5 mph)
 - Select a roller speed that is with the range for impact spacing based on frequency
 - Also consider an efficiency factor (account for change in direction, water refills, etc)
- Need to account for roller passes to cover paving width (assume 84 in drum w/ 6 in. overlap)
- 12 (ft)/ (7-0.5) ft = 1.85 Passes or 2 passes for coverage of entire width
- 14 (ft)/ (7-0.5) ft = 2.15 Passes or 3 passes for coverage of entire width

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Calculate Paver Speed Based on Compaction



Input	Jim's Crew	Randy's Crew
Plant Production (tons per hour)	190	290
Width of Pull (ft)	12	14
Paver Speed – Plant (ft/min) at 90% Eff.	24.0	41.9
Passes for Coverage	2	3
Passes Need for Density	3	4

- Based on the test strip, Jim's crew need 3 passes for density; Randy needs 4
- The compaction production rate is based on effective roller speed and total passes required

Randy's Crew

 $Total\ Passes = Passes\ for\ Coverage\ \times Passes\ for\ Density$

 $2 \times 3 = 6$ Total Passes $3 \times 4 = 12$ Total Passes

$$Paver\ Speed = \frac{Effective\ Roller\ Speed\ \frac{ft}{min}}{Total\ Passes}$$

$$\frac{222 \frac{ft}{min}}{6} = 37.0 \frac{ft}{min}$$

Jim's Crew

$$\frac{222 \frac{ft}{min}}{6} = 37.0 \frac{ft}{min}$$
 $\frac{222 \frac{ft}{min}}{12} = 18.5 \frac{ft}{min}$

Establishing Paver Speed



Input	Jim's Crew	Randy's Crew
Plant Production (tons per hour)	190	290
Width of Pull (ft)	12	14
Paver Speed – Plant (ft/min) at 90% Eff.	24.0	41.9
Passes for Coverage	2	3
Passes Need for Density	3	4
Paver Speed – Compaction (ft/min.)	37.0	18.5

- Paver speed must be balanced with the rate of mixture delivery and the rate of densification by the rollers.
- The results that indicate the <u>slower</u> paver speed is what will control to create a proper balance in the paving operations.
- What speed should Jim's crew set for the paver?
- What speed should Randy's crew need to target?
- What other options exist for Randy's crew?

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Options for Randy's Crew



- Option 1: Run paver at 18.8 ft/min
 - Slow everything else down
 - Plant and Trucking
- Option 2: Add a breakdown roller
 - Extra roller provides added passes at same speed
 - ∘ Run paver at 37 38 ft./min
 - Minimize Paver Stops (Higher efficiency)
 - Adjust Plant Production Accordingly
- Option 3: Add second breakdown and another intermediate roller
- Option 4....

Final Thoughts



- Set your goals and develop a plan
- Remember: Everyone has a plan until:
 - Truck goes down
 - Rolling pattern needs adjusted
 - Plant is down
 - Cycle time increases
 - Any others?
- Communication and composure is critical!
- Remember the moving parts and balance
- Industry of Continuous Improvement





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Dad, there's an app for that!





Caterpillar Paving Calculator 4+ Caterpillar Inc.

Designed for iPad

★★★★ 2.0 • 25 Ratio

Free



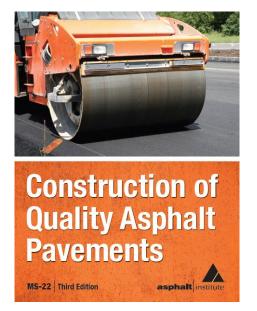
Asphalt Pro 4+
Post River Software
**** 5.0 • 6 Ratings

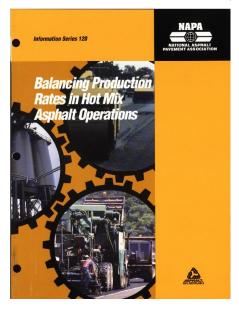
Eroo

- May only be available for iOS
- Build a spreadsheet

References







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Thank-you AI Members!!



Dave Johnson, P.E. Asphalt Institute, Rocky Mountain Region

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406-794-7454

My contact information



COLD IN-PLACE RECYCLING: *TECHNIQUES & PERFORMANCE INSIGHTS*



ADAM HAND









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OUTLINE

Introduction and Background

NCHRP Synthesis Highlights

TechBrief Highlights

Recent & Future Interesting Project Highlights

Resources









COLD RECYCLING METHODS

- Cold In-place Recycling
 - CIR
- Full Depth Reclamation
 - FDR emulsion, foamed asphalt, or cement
- Cold Central Plant Recycling
 - CCPR







Images Source: A. Hand









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BACKGROUND

- Agencies facing increased material costs
- Asphalt Industry recycling history
- RAP supply urban vs. rural
- Reduce cost, energy consumption, natural resources, construction duration, and road user delays
- Pavement geometry corrected, preserve overhead clearances, improving structural capacity and performance
- Reuse some or all existing pavement materials

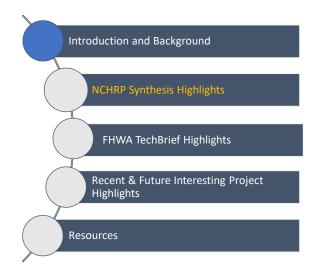


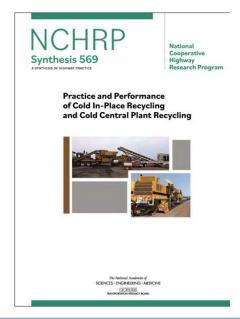






OUTLINE













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NCHRP SYNTHESIS 569

- "A total of 40 agencies responded... Most cold recycling programs pave less than 50 lane-miles per year. Cold recycling is frequently used on roadways with annual average daily traffic (AADT) under 10,000, but more experienced agencies use cold recycling on roadways with AADTs between 10,000 and 25,000."
- "The reported service life of cold recycled pavements ranges from 20 to 34 years
 when the cold recycled mix is used in conjunction with an overlay. The service life
 is somewhat shorter and more variable when chip seals are used as the wearing
 surface. Poor drainage can reduce the service life by 30% or more."
- "Cold recycling with an overlay can reduce the cost of a project by 40% to 60% compared to a conventional mill and fill. Greenhouse gas emissions can be reduced by about 50% compared to a conventional mill and fill."

Source: https://nap.nationalacademies.org/catalog/26319/practice-and-performance-of-cold-in-place-recycling-and-cold-central-plant-recycling

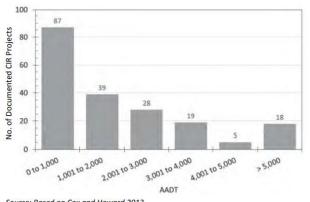


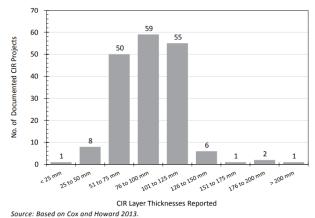






NCHRP SYNTHESIS 569





Source: Based on Cox and Howard 2013.

Figure 1. Documented traffic levels.

Figure 4. CIR layer thicknesses reported in documents.

Source: NCHRP Synthesis 569







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NCHRP SYNTHESIS 569

Table 8. Structural layer coefficients found in the literature.

Location	Structural Layer Coefficient	Recycling Agents, Comments	Source
Indiana	0.22	Recycled base	Cosenza and Robinson 2019
New Mexico	0.25	No information	Jahren et al. 2016
Nevada	0.23 to 0.26	Based on fatigue analysis	Carvajal 2018
Nevada	0.28	No information	Jahren et al. 2016
Kansas	0.25 to 0.28	No information	Jahren et al. 2016
Oregon	Considered equivalent to conventional asphalt mixes	No information	Cox and Howard 2015
Quebec	0.30	No information	Carter et al. 2013
General	0.30	Used in analysis	Cross et al. 2010
AASHTO 1993 design guide	0.32	No information	Schwartz et al. 2017
General	0.28 to 0.33	AASHTO 93	Wielinski 2017
General	0.25 to 0.35	0.30 to 0.35 most common	Wagner 2018
General	0.30 to 0.35	No information	Cross 2014
General	0.26 to 0.36	HF recycling agent CIR*	Cox and Howard 2015
Virginia I-81	0.39	Foamed asphalt CCPR, CIR	Cross 2014
National Center for Asphalt Technology Test Track	0.40	Foamed asphalt CCPR, CIR	Schellhammer 2019
VDOT	0.36 to 0.44	No information	Wagner 2018
General	0.17 to 0.44	Emulsion CIR	Cox and Howard 2015
General	0.45	CMS-2 emulsion CIR	Cox and Howard 2015

*HF = high float.

Source: NCHRP Synthesis 569









MARSHALL STABILITY AND ITS

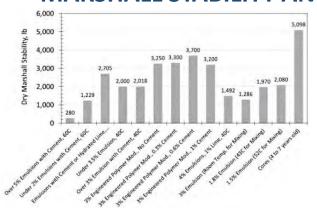


Figure 17. Examples of dry Marshall stabilities for emulsified cold recycled mixes.

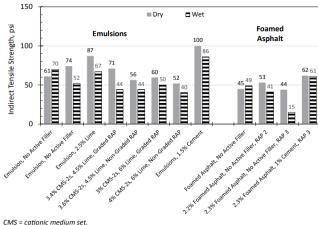


Figure 18. Comparison of indirect tensile test strength, wet and dry, for emulsions and foamed asphalt cold recycled mixes.

Source: NCHRP Synthesis 569









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OUTLINE



TechBrief

The Asphalt Pavement Technology Program is an integrated national effort to improve the long-term performance and cost-effectiveness of asphalt powers. Administration through pavements. Managed by the Federal Highway Administration through pavements, Managed by the Federal Highway Administration through pavements, Managed by the Federal Highway and the Federal Hig

Office of Preconstruction Construction, and Pavements FHWA-HIF-23-036



Asphalt Pavement Recycling Technologies

This Technical Brief summarizes techniques successfully used by State DOTs and Federal Lands Highway Divisions to implement use of cold asphalt and hot in place asphalt recogling technologies

he contents of this document do not have the force and effect of wand are not meant to bind the public in any way. This document intended only to provide clarity to the public regarding existing quirements under the law or agency policies.

ntroduction

facing greater pressure to integrate sustainability into powement construction and readoce material costs at the same time." The asphalt industry recycles over 99 percent of reclaimed asphalt presented (RAP) for majority of it in recycled back in asphalt speciment (RAP) for majority of it in recycled back in asphalt speciment (RAP) for majority of it in recycled back in asphalt alternatives to virgin asphalt intofer initially, in some urban areas, alternatives to virgin asphalt intofer initially, in some urban areas, and amounted of the present as a variable supply of RAP can be less than outside practice. This challenge can be addressed using a sustainable practice. This challenge can be addressed using a sustainable practice. This challenge can be addressed using a Association (RAPA) 2021 construction asson survey stated that 25 companies collectively indicated that they used over 4.8 million tons Association (RAPA) 2021 construction season survey stated that 25 companies collectively indicated that they used over 4.8 million tons of the construction season. The recycling precesses during the 2021 construction season.

This TechBrief focuses on these sustainable asphalt pavement recycling techniques (APRT): cold in-place recycling (CIR), full depth reclamation (FDR), cold central plant recycling (CCPR), and hot in-place recycling (HIPR).

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Source: FHWA HIF-23-036

https://www.fhwa.dot.gov/pavement/recycling/apiprt/HIF Asphalt Pavement Recycling Technologies Tech Brief.pdf









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OBJECTIVES

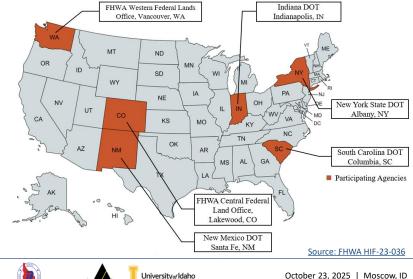
- Learn details of positive State DOT practices
- Collect and communicate experiences, lessons learned and performance information
- Identify gaps for creation of research needs statements
- Supplement FHWA, ARRA, AASHTO & other documents



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PARTICIPATING AGENCIES

- 6 agencies:
 - FLH
 - INDOT
 - NMDOT
 - NYSDOT
 - SCDOT
 - VDOT
- Virtual site visits and interviews





SCOPE

- CIR, CCPR, FDR & HIR
- Kick-off/planning meeting
- 2 or 3 day virtual visits
- Agency reports
- Summary report
- FHWA TechBrief
- Webinar

TechBrief

The Asphalt Pavement Technology Program is an integrated national effort to improve the long-term performance and cost-effectiveness of asphalt pavements. Managed by the Federal Highway Administration through partnerships with State highway agencies, industry, and academia, the program's primary goals are to reduce congestion, improve congestion, improve safety, and foster The program was established to develop and implement suggestions, methods, procedures, and other tools for asphalt pavement materials selection, mixture design, testing, construction, and quality control.

Office of Preconstruction, Construction, and FHWA-HIF-23-036 Date: July 2023



Asphalt Pavement Recycling Technologies

This Technical Brief summarizes techniques successfully used by State DOTs and Federal Lands Highway Divisions to implement use of cold asphalt and hot in-place asphalt recycling technologies.

The contents of this document do not have the force and effect of law and are not meant to bind the public in any way. This document is intended only to provide clarity to the public regarding existing requirements under the law or agency policies.

Introduction

State Departments of Transportation (DOT) and other agencies are facing greater pressure to integrate sustainability into paveneral facing greater pressure to integrate sustainability into paveneral facing greater pressure to integrate sustainability into paveneral facility, the property of the service of the part appearance (RAP), the majority of it is recycled beak in aphalt paveneral (RAP). The majority of it is recycled beak in aphalt paveneral facility in apalta blaner intitially. In some unbrush areas, RAP supply exceeds domand, reading in apalta blaner intitially, In some unbrush areas, RAP supply exceeds domand, reading caces RAP from what to rural areas is not a sustainable practice. This challenge can be addressed using patterned to increase recycling rates. A National Apphalt Paveneral excess to irrecess recycling rates. A National Apphalt Paveneral examples of the particular particular plant particu

This TechBrief focuses on these sustainable asphalt pavement recycling techniques (APRT): cold in-place recycling (CIR), full depth reclamation (FDR), cold central plant recycling (CCPR), and hot in-place recycling (HIPR).

Cold recycling is a method of reconstructing any flexible powerent where the need arises from structural failures. CIR is a powerent reliabilitation method in which some fraction of the existing powerent thickness (up to about 4 inches) is milled up, resulted and screened, then mixed with asphalt cement (or emulsified/Sundapalta) and replaced to serve as a high-aulity base material upon which to pace. WFDR is a pavement rehabilitation method in which the existing full pavement thickness and some perition of the underlying material is pulverized, blended, and stabilized (with quality base material upon which to you. HIPR is a prevenent rehabilitation method in which the existing asphalt pavements under the control of the control of

Source: FHWA HIF-23-036

https://www.fhwa.dot.gov/pavement/recycling/apiprt/HIF Asphalt Pavement Recycling Technologies Tech Brief.pdf









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AGENCY USE OF TECHNOLOGIES

Recycling Technologies Used

Item	FLH	INDOT	NMDOT	NYSDOT	SCDOT	VDOT
CIR	Yes	Yes	Yes	Yes	No	Yes
CCPR	Yes	Yes	Yes	V. Limited	No	Yes
FDR	Yes	Yes	Yes	No	Yes	Yes
HIR	No	No	Yes	Yes	No	No

Years of Experience

Item	FLH	INDOT	NMDOT	NYSDOT	SCDOT	VDOT
CIR	50	5-10	3	20+	n/a	10 ⁺
CCPR	15	5-10	8	5 ⁺	n/a	10+
FDR	40	5-10	9	n/a	7	13+
HIR	50	n/a	20+	15 ⁺	n/a	n/a

Source: FHWA HIF-23-036









AGENCY USE OF TECHNOLOGIES

Percentage of Recycling Program

Item	FLH ¹	INDOT	NMDOT	NYSDOT	SCDOT	VDOT
CIR	6% (5%)	38%	10%	50 to 65%	0%	20%
CCPR	6% (5%)	12%	40%	<1%	0%	18%
FDR	88% (80%)	50%	50%	0%	100%	62%
HIR	0%	0%	n/a	35 to 50%	0%	0%

^{1≈10%} of FLH Recycling in RAP Millings

Source: FHWA HIF-23-036









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PROJECT/RECYCLING TECHNOLOGY SELECTION CRITERIA

- Very Important
- Some Examples:
 - FLH
 - https://highways.dot.gov/federal-lands/specs
 - INDOT
 - https://www.in.gov/dot/div/contracts/design/Part%206/Chapter%20602%20-%20Project%20Categories%20and%20Pavement%20Types.pdf
 - NYSDOT
 - https://www.in.gov/dot/div/contracts/design/Part%206/Chapter%20602%20-%20Project%20Categories%20and%20Pavement%20Types.pdf
 - FHWA Tech Brief: Overview of Project Selection Guidelines for Cold In-place and Cold Central Plant Pavement Recycling
 - https://www.fhwa.dot.gov/pavement/asphalt/pubs/hif17042.pdf

Source: FHWA HIF-23-036









PROJECT SELECTION: CHARACTERISTICS OF A GOOD CANDIDATE

- End of service life
- Minor patching
- Fatigue cracking
- 3-inch thickness minimum



Source: FHWA









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PROJECT SELECTION: CHARACTERISTICS OF A POOR CANDIDATE



- Road geometry: grade and curves
- Less than 3 inches
- · Geotextile in milling depth
- Need to tie into existing structures

Source: FHWA

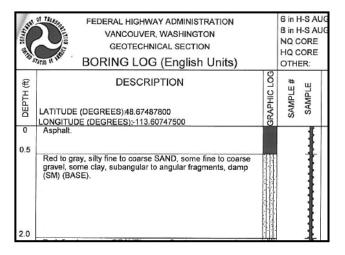








Average Distance between Borings	2674 feet
Average Thickness of Pavement	4.2 inches
Controlling Thickness	3.6 inches



Boring No.	Station	Distance Between Borings (ft)	Pavement Depth (in)
SG03-45	2059+70	2640	3.8
SG03-46	2086+10	2700	4
SG03-47	2113+10	2640	3.6
SG03-48	2139+50	2680	4.2
SG03-49	2166+30	2676	5
SG03-50	2193+06	2680	3.6
SG03-51	2219+86	2654	4.5
SG03-52	2246+40	2760	4
SG03-53	2274+00		5

Source: FHWA HIF-23-036





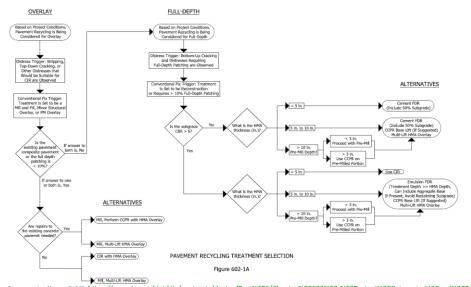




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INDOT PAVEMENT TREATMENT SELECTION



Source: Indiana DOT https://www.in.gov/dot/div/contracts/design/Part%206/Chapter%20602%20-%20Project%20Categories%20and%20Pavement%20Types.pdf

WOLF







STRUCTURAL PAVEMENT DESIGN

- AASHTO 1993: FLH, NMDOT, SCDOT, VDOT (rehab)
- AASHTOWare Pavement[™] ME Design: INDOT, NYSDOT, VDOT (new)

Item	FLH	INDOT	NMDOT	NYDOT	SCDOT	VDOT
CIR	0.28-0.30	75-100ksi	0.35	n/a¹	n/a	0.35
CCPR	0.25-0.30	75-100ksi	0.35	n/a	n/a	0.35^{2}
FDR AC	0.20-0.25	75-100ksi	0.30	n/a	n/a	0.25
FDR PC	0.15-0.22	75-100ksi	n/a	n/a	0.26	0.25

¹NYSDOT typically very thick pavements, so no formal structural design is performed.

²VDOT used aggregate base thickness multiplied by 1.26 for CCPR in AASHTOWare Pavement™ ME Design.

Source: FHWA HIF-23-036









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CIR MATERIALS SELECTION – BINDERS & ACTIVE FILLERS

Item	FLH	INDOT	NMDOT	NYSDOT	VDOT
Binders	Engineered Emulsion	Emulsion	Engineered Emulsion	Emulsion, PM Emulsion, PG64S-22 Foamed Asphalt	Emulsion or Foamed Asphalt
Active	Portland	Portland	Portland	1% Portland	Portland
Filler	Cement or	Cement	Cement or	Cement	Cement
	Lime Slurry	Allowed	Lime		

Terminology...binder, stabilizing agent, active fillers

Source: FHWA HIF-23-036

CIR Example – Same for CCPR, FDR_{AC} , FDR_{PC} in FHWA HIF-23-036



Source: FHWA HIF-23-036

F-23-036



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CIR MIX DESIGN

	FLH	INDOT	NMDOT	NYSDOT	VDOT
Compactor	Gyratory-35	Gyratory-30	Gyratory-30	Gyratory-30	Marshall-75
Emulsion	Indirect	Marshall	Indirect Tensile	Indirect Tensile	Marshall
	Tensile	Stability &	Strength & TSR	Strength & TSR	Stability &
	Strength &	Retained	Coating,	or Retained	Retained
	TSR	Stability,	Raveling	Marshall	Stability
		Raveling		Stability	
Foamed	n/a	n/a	n/a	Indirect Tensile	Indirect Tensile
				Strength & TSR	Strength & TSR,
				or Retained	Half-Life
				Marshall	
				Stability	

Source: FHWA HIF-23-036









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QUALITY CONTROL & ACCEPTANCE

6 Core Elements of a QA Program



Source: FHWA HIF-23-036

Most Common Production QC

- Binder
- Moisture
- Gradation top size
- Density
- Thickness
- Curing









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CIR & CCPR CURING & OPENING TO TRAFFIC

Item	FLH	INDOT ¹	NMDOT	NYSDOT	VDOT
Traffic	0 for 2 hours	-	0 for 2 hours	-	0 for 2 hours
Moisture	≤ 2.5%	≤ 3.0%	≤ 3.0%	-	≤ 50% of
Content					optimum
					moisture
					content
Time	Cover within	≥ 3 days	≥ 3 days	Emulsion ≥	-
	14 days	or		10 days;	
		10 days		Foamed	
		without		Asphalt ≥ 3	
		rainfall		days	

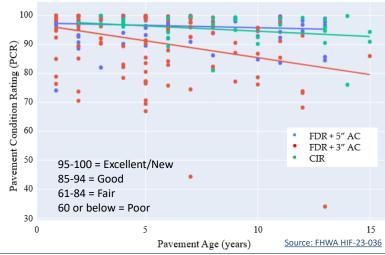
 1 Greater than 3 days and less than 3.0% moisture or cured 10 days without rainfall. $_{\rm Source:\ FHWA\ HIF-23-036}$



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CIR & FDR PERFORMANCE

- · Federal Lands Highways Performance
 - CIR
 - FDR
- PCR = 0.6 (SCR) = 0.4 (RCI)
 - SCR = Surface Condition Rating
 - Rutting, cracking, patching
 - RCI = Roughness Condition Rating
 - IRI





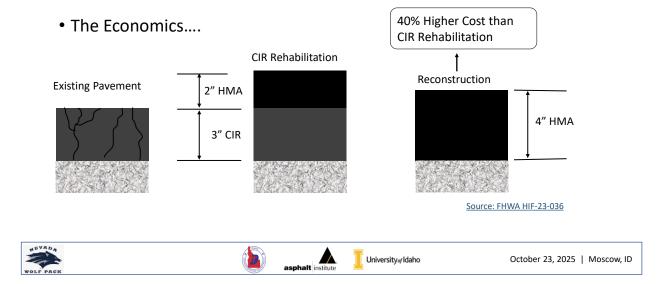






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FLH: CIR COST AND PERFORMANCE



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PERFORMANCE – ICE HOUSE ROAD EL DORADO NATIONAL FOREST, CA



wolf Pack

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PERFORMANCE – WASHINGTON ROAD TAHOE NATIONAL FOREST, CA







2019 – 10 years old Images Source: FHWA









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Performance – Rocky Mountain National Park, CO



Images Source: FHWA





After 26 years









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SUGGESTED PRACTICES

- Pre-Construction
 - Detailed treatment selection guide
 - · Regularly updated specifications
 - Adequate site investigation
 - · Representative samples
 - Pre-construction meetings (all SH 4-8 hours)
- Mix Design
 - Accredited labs
 - Using AASHTO MPs & PP's
 - · Leveraging engineered emulsions

- Production & Acceptance
 - Requiring QC Plans
 - · Control or test strips for density
 - Proof rolling requirement
 - On-site technical representative
 - Monitor yield daily
 - Maintenance/traffic control while curing
 - Pay for binder as separate item
- Programmatic
 - Post-project/season stakeholder meetings
 - Collecting performance data

Source: FHWA HIF-23-036









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LESSONS LEARNED

- Use large enough minimum project sizes
- Without detailed site investigation variability can create issues
- Adequate drainage is essential
- Don't overlook geometric constraints (underpasses, drainage inlets, guardrail height, etc.)
- If significant changes in cross section (subgrade, mc, thickness), may require more than one mix design

- If correcting geometry (grades/cross slopes) be sure adequate recycled layer thickness
- Leave adequate pavement structure in-place
 - Do not include aggregate base in CIR
- Require mix designs and QCPs 30 days prior to production
- Recognize recycled layer "fluffs"
- In high moisture, portland cement helps with strength









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Source: FHWA HIF-23-036

LESSONS LEARNED

- Night work, early season, cool temps, CIR emulsion breaking
- Change milling speed, moisture & temperature affect gradation & density
- Calibrate equipment
- Keep rollers back from paver on CIR, not like HMA
- Contractor and inspector experience with new technologies important
- HMA tech ≠ CIR tech
- Tack coats are helpful
- Post-project/season stakeholder meetings

Source: FHWA HIF-23-036

Source: FHWA HIF-23-036

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OUTLINE





VDOT I-64, WILLIAMSBURG, VA

Segment II, 2017-2019

- East and Westbound lanes, reconstruct existing lanes, add new lane and shoulder
- 2020 AADT = 36,000 vpd with 8% trucks
- VDOT found recycling viable for rapid reconstruction and significant cost savings
- FHWA publication also identified environmental savings
- Largest recycling project in North America at the time of construction
 - 7.08 miles, 71 lane miles
 - 168,000 tons CCPR
 - 345,000 SY FDR
 - 146,000 tons imported FDR

Segment III, 2018-2021

- East and Westbound lanes, reconstruct existing lanes, add new lane and shoulder
- 2020 AADT = 37,000 vpd with 5% trucks
- VDOT found recycling viable for rapid reconstruction and significant cost savings
- FHWA publication also identified environmental savings
- Largest recycling project in North America at the time of construction
 - 8.32 miles, 83 lane miles
 - 195,670 tons CCPR
 - 229,100 SY FDR
 - 201,050 tons imported FDR

Source: Virginia DOT, VTRC







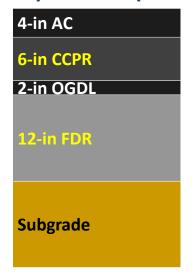


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I-64 SEGMENTS II (LEFT) AND III (RIGHT)

- FDR
 - Existing foundation in reconstruction lanes
 - Imported crushed concrete in new lanes
- CCPR
 - From <u>existing</u> RAP stockpiles
- CSS
 - Cement stabilized subgrade in new lanes for Segment III





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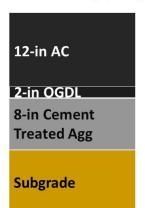




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I-64 SEGMENT II

- Original design (left) vs recycling design (right)
- Cost savings ranged from \$22 to \$43/SY
 - Imported FDR lanes had higher SY cost



SN = 7.08, \$83/SY SN = 7.06, \$40-61*/SY



Source: Virginia DOT, VTRC









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AASHTO PP86-20.pdf AASHTO PP 94-18.pdf

AASHTO MP31-17.pdf

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NCHRP PROJECT 14-43

NCHRP 14-43 [Final]

AASHTO MP38-18.pdf Construction Guide Specifications for Cold Central Plant Recycling and Cold In-Place Recycling

Project Data Funds: Research Agency: National Center for Asphalt Technology Principal Investigator: Benjamin Bowers Effective Date: 5/26/2020 Completion Date: 8/31/2022 Comments: Report Published as NCHRP Web-Only-Document 363

The objective of this research was to produce proposed AASHTO Construction Guide Specifications for the application of CCPR and CIR in the standard five-part AASHTO format with supporting commentary. The specifications shall include plans for quality assurance and agree with current provisional material specifications and mix design practices for these treatments. The specifications shall enable specifying agencies to tailor their own specifications to the local conditions and environments.

STATUS: Project's Report Published as NCHRP Web-Only-Document 363 (https://www.trb.org/Publications/Blurbs/182965.aspx).

NCHRP Web-Only-Document 363 https://www.trb.org/Publications/Blurbs/182965.aspx









NCHRP PROJECT 09-62

NCHRP 09-62 [Completed]

Rapid Tests and Specifications for Construction of Asphalt-Treated Cold Recycled Pavements

Project Data

Funds: \$999,737

Research Agency: Virginia Transportation Research Council

Principal Investigator: Brian Diefenderfer

Effective Date: 6/1/2017

Completion Date: 8/31/2022

Comments: Publication pending

NCHRP Project 09-62 was awarded in 2017 with the following objectives: develop (1) time-critical tests for asphalt-treated cold in-place recycling (CIR), full-depth reclamation (FDR), and cold central plant recycling (CCPR) materials and (2) a guide specification using these tests for process control and product acceptance that provides the agency with a basis for determining when the pavement can be opened to traffic and surfaced.

NCHRP Research Report 960, Proposed AASHTO Practice and Tests for Process Control and Product Acceptance of Asphalt-Treated Cold Recycled Pavements









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- Time-critical tests for asphalttreated CIR, CCPR & FDR materials, and
- Guide specifications for using these tests for process control and product acceptance that provide agencies with a basis for determining when the pavement can be opened to traffic and/or when it can be resurfaced



Rutting Under Traffic Prior to Surfacing

Raveling Under Traffic Prior to Surfacing

Images Source: A. Hand











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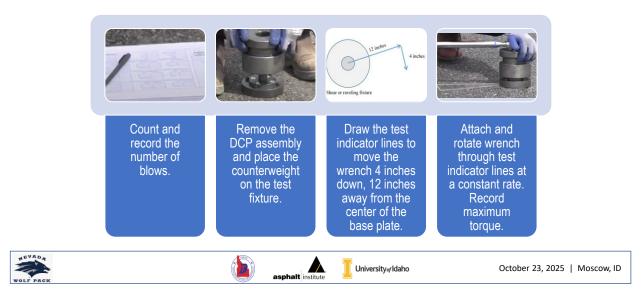
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During Construction: NCHRP 9-62 (Cont.)



During Construction: NCHRP 9-62 (Cont.)



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During Construction: NCHRP 9-62 LPST & SPRT Data All thresholds met after 24 hours **Short Pin Raveling Test (SPRT)** Long Pin Shear Test (LPST) ■MP 5.8 SB ■MP 6.6 SB ■MP 7.6 SB # of Blows After Initial Compaction After Initial Compaction After 1 hour After 2 hours After 24 hours Torque (ft-lbs.) 32 35 36 35 35 After Initial Compaction After 2 hours After 24 hours After Initial After 1 hour After 2 hours After 24 hours Time Of Compaction (Hours) Time Of Compaction (Hours) University of Idaho October 23, 2025 | Moscow, ID asphalt institu

AAPTP CCPR PROJECT



ABOUT NAPA

EXPERTISE

PROGRAMS

MEMBERSHIP

NEWS & RESOURCES

AAPTP HOME

REQUESTS FOR PROPOSALS

PROJECT COORDINATION GROUP

FEASIBILITY OF COLD CENTRAL PLANT RECYCLING (CCPR) ASPHALT MIXTURES FOR **AIRPORTS**

With the Administration setting the goal that the United States will be carbon neutral by 2050, all industries are being asked to consider how they can contribute to making this goal reality. Recently, Cold Central Plant Recycling (CCPR) has been used by some agencies to reduce energy demands and research has suggested that CCPR mixtures can perform well on highways; however, little research has been conducted to show the feasibility for this type of mixture on airfields. The objective of this project is to assess the feasibility and potential benefits of using CCPR asphalt mixtures at all categories of airports.









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NAPA AAPTP CCPR PROJECT

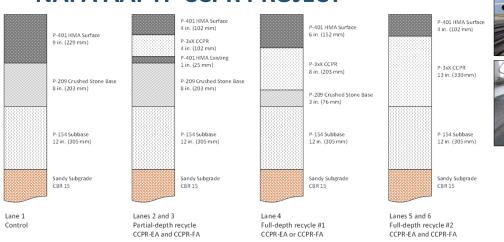


Figure 7.25: Proposed test track designs.









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Rejuvenation of Cold Recycled Asphalt Mixtures

Blacklidge Emulsions, Ingevity, United Soybean Board, Pavement Restorations, inc.

Benjamin F. Bowers [PI], R. Buzz Powell [Co-PI]

Can we move CCPR performance closer toward HMA, creating a cost effective, low emission, equitable solution for communities? Good early performance!





DEVELOPMENT OF A BALANCE MIX DESIGN FOR COLD IN-PLACE RECYCLING & SUCCESSFUL PROJECT CONSTRUCTION



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CIR PILOT PROJECT OBJECTIVES

- **Objective:** Explore and implement a performance-based specification for CIR through agency-industry-academia collaboration.
- Needs: A challenging site with commonality to be reproduced on future project site.
 - Cores
 - Millings/slabs
- How: Through appropriate performance-based testing including:
 - NDOT Mix Design Method Hveem
 - Indirect Tensile Strength Test
 - Hamburg Wheel Track Test
- Acknowledgements: NDOT Materials & Maintenance, Industry, UNR



CIR PILOT PROJECT EXPERIMENTAL PLAN











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STATE ROUTE (SR) 232

- SR 232, Clover Valley Road
 - Beginning of pavement North of US93 at the north intersection
- Elko County, Nevada
 - · South of Wells
- Low volume road
- Double chip seal
 - Last chip seal placed in 2017



Characterization	Previous Project Sites	SR 232	
Existing Surface Layer	HMA	Double Chip Seal	
Existing Pavement Structure	HMA/CAB/SG	DGA & Road Mix/SG	
Traffic (AADT)	250	160	



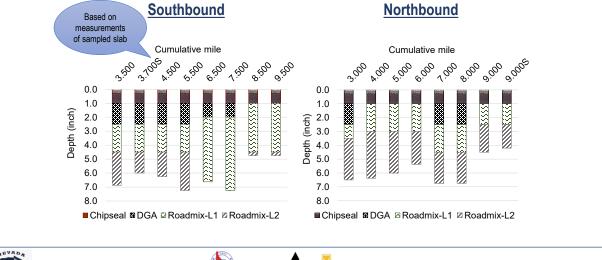






PRELIMINARY LABORATORY EVALUATION

LOG CHART—APPROXIMATED FROM CORE PICTURES



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PRELIMINARY LABORATORY EVALUATION (CONT.)

SLAB PROCESSING – RAP ASPHALT BINDER CONTENT

• Ignition oven method (AASHTO T 308)*

	MP 3.7 SB- DGA	MP 3.7 SB- Roadmix	MP 3.7 SB- Chipseal	MP 9.0 NB- Roadmix	7 7
Binder Content, %TWM	8.1	8.4	12.8	8.7	13.5

^{*}No asphalt or aggregate correction factors applied.

Verification: Extraction (AASHTO T 164)

	MP 3.7 SB- DGA	MP 3.7 SB- Roadmix	MP 3.7 SB- Chipseal	MP 9.0 NB- Roadmix	
Binder Content, %TWM	-	5.6	-	-	-
Recovered binder PG-High	-	51.9	-	-	-









PRELIMINARY LABORATORY EVALUATION (CONT.)

CIR HVEEM MIX DESIGN

- 1% water content and 4.5% lime slurry
- 2.5% and 3.0% asphalt emulsion (PASS-R)
- · Hveem method
 - · 25 tamps at 250 psi
 - 100 tamps at 500 psi
 - 300 psi of leveling stress
 - 4-in. Hveem mold (not perforated)
 - Target air void of 13±1%
- Hveem Stability (AASHTO T246)
 - · At 25°C with no curing
 - At 25°C after curing for 24 hours at 60°C













Adjusted from HMA

Hveem mix design



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PRELIMINARY LABORATORY EVALUATION (CONT.) CIR PERFORMANCE TESTS



- AASHTO T283: Indirect Tensile Strength Test
 - IDEAL-CT (ASTM D8225) conducted on same samples
 - 1 & 3 freeze thaw cycles
 - 150 mm SGC sample
 - Perforated mold
 - Target air void of 13±1%



- AASHTO T324: Hamburg Wheel Track Test (HWTT)
 - Test temperature 50°C







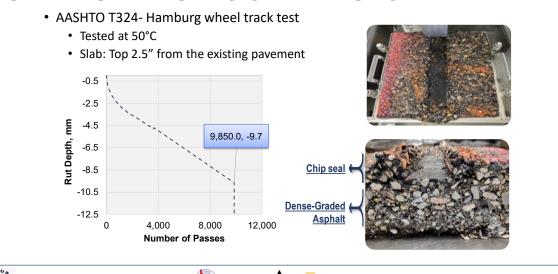






PRELIMINARY LABORATORY EVALUATION (CONT.)

CIR PERFORMANCE TESTS – HWTT ON SLAB



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PRELIMINARY CONCLUSIONS

- Selected 3.0% emulsion as the OEC
 - · Changed emulsion to include harder base binder
 - Referenced as CIR-h
 - · Addition of additives:
 - Ratio of residual asphalt to dry cement 2.5:1
 - · Limited to 1.0% by dry weight of RAP
 - Use of Quicklime (CaO) at 33% of the total lime slurry

After discussion with industry based on previous project experience

Stability

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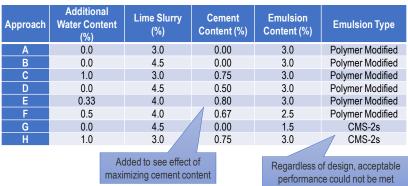




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Mix Design Approaches

- Total of 8 mixtures tested throughout the course of the project
 - · Selected based on discussions with agency and industry
- Approach A-D conducted using slab crushed material
- Approach E-H conducted using field millings











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Process

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MIX DESIGN

EXPERIMENTAL PLAN

	Hveem mix design	TSR (AASHTO T283)		IDEAL-CT			Hveem
CIR Mixture	verification	1 F-T	3 F-T	1 F-T	3 F-T	HWT	Stability
% Air Voids	13±1 %	13±1 %	13±1 %	13±1 %	13±1 %	13±1 %	13±1 %
A	✓	✓	✓	✓	✓	✓	✓
В	✓	✓	-	✓	-	✓	-
С	✓	✓	✓	✓	✓	√	✓
D	✓	✓	✓	✓	✓		✓
Е	✓	✓	-	✓			, , , , ,
F	✓	✓	-	✓	Als	Also conducted slab materi without chipseal	
G	✓	✓	-	✓			
Н	✓	√	-	✓	-	✓	_

Continuously changing plan as discussions over findings took place and due to time constraints, not all approaches were tested for every specification

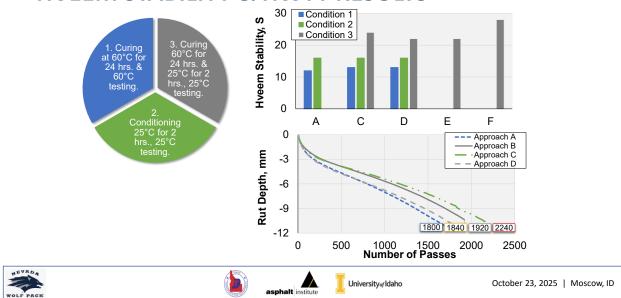






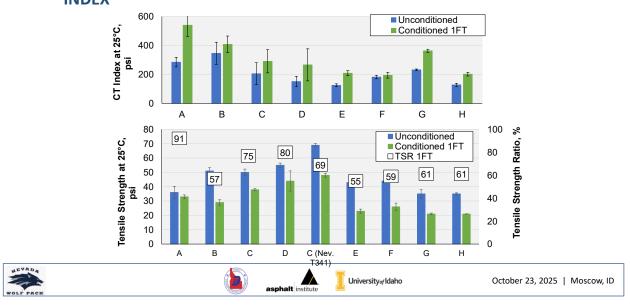


HVEEM STABILITY & HWTT RESULTS



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MIX DESIGN (CONT.) CT_{INDEX} & TSR RESULTS



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MIX DESIGN (CONT.)

MIX DESIGN RECOMMENDATION

CIR Mixture Properties	Test Method	Approach A	Approach B	Approach C	Approach D
Emulsion, %		3.0	3.0	3.0	3.0
Lime Slurry, %		3.0	4.5	3.0	4.5
Cement, %		0.0	0.0	0.75	0.5
Additional Water, %		0.0	0.0	1.0	0.0
Hveem Mix Design Air Voids, %	ASTM D1188	12.8	12.9	12.1	12.7
Hveem stability immediately after compaction @25°C	AASHTO T246	16	-	16	16
Hveem stability at 25°C after curing 24 hr @60°C	AASHTO T246	-	-	24	22
HWT: No of passes to reach 12.5 mm rut depth	AASHTO T321	1800	1920	2240	1840
Tensile strength (dry), psi	AASHTO T283	36	51	50	55
Tensile strength (wet after 1 FT), psi	AASHTO T283	33	29	38	44
Tensile strength (wet after 3 FT), psi	AASHTO T283	32	-	35	31
Tensile strength ratio after 1 FT	AASHTO T283	91	57	75	80
Tensile strength ratio after 3 FT	AASHTO T283	87	-	71	58
CTI (Dry)	AASHTO T225	285	346	205	151
CTI (Wet after 1 FT)	AASHTO T225	540	408	291	266
CTI (Wet after 3 FT)	AASHTO T225	443	-	213	206
					,





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Contract and Specifications

Specification Changes

Standard Specifications for Road and Bridge Construction (NDOT Silver Book) - Section 404 Cold Recycle

- 2001
 - Recycling Agent 1.5% w/ adjustment by concurrence
 - Milling Machine Section 202
 - · Rates tied to forward motion
 - Pneu. Rollers 2 each 25 ton
 - Double steel 10 ton
 - Paving rain delay < 1% MC CIR
 - · Comp. without undue displacement or cracking
 - Comp. Method C "wet" control strip

- 2014
 - Recycling Agent CMS-2s 1.5% w/ adjust. (1.25-1.75 limit)
 - Section 202 with upcut direction
 - · Rates tied to forward motion
 - Pneu. 15-25 ton and 25-30 ton
 - Double steel 2 each 10 ton
 - < 2% MC CIR</p>
 - · Long. Joint first, then compact low to
 - Comp. Method C "wet" control strip









Contract and Specifications (Cont.)

Specification Changes (Cont.)

Standard Specifications for Road and Bridge Construction (NDOT Silver Book) – Section 404 Cold Recycle

- 2014
- Recycling Agent CMS-2s 1.5% w/ adjust. (1.25-1.75 limit)
- Section 202 with upcut direction
- · Rates tied to forward motion
- Pneu. 15-25 ton and 25-30 ton
- Double steel 2 each 10 ton
- < 2% MC CIR
- · Long. Joint first, then compact low to high
- Comp. Method C "wet" control strip

- 2021 Specials (Gen 3)
- Recycling Agent PMPS-CIRh Mix design with char. tests
- JMF Emuls., water, lime, cement
- Section 202 upcut/concur REApplications tied to weigh belt
- Pneu. 15-25 ton and 25-30 ton
- Double steel 2 each 10 ton
- <2% MC CIR
- · Long. Joint first, then compact low to high
- Comp. Nuc backscatter corr. Sandcone, 86-95% Rice density









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Specifications – Mix Design

Section 404 Cold Recycle: 2021 Specials (Gen 3)

TEST	TEST METHOD	REQUIREMENTS
Percent Air Voids of Compacted Cold Recycle Mixture (after 24 hr cure at 60°C, prior to Nev T303)	AASHTO T269	13%*
Stabilometer Value (Tested at 25°C after 24 hr cure at 60°C)	Nev. T303	20 Min.
Indirect Tensile Strength (Unconditioned)	Nev. T341	50 psi Min.
Indirect Tensile Strength (Retained Strength)	Nev. T341	65% Min.

^{*} The mix design percent air void requirement may be adjusted by the Department to obtain passing values for other mix design requirements.

Slab → Millings → Production









Contract and Specifications (Cont.)

Specifications – Job Mix Formula

Section 404 Cold Recycle: 2021 Specials (Gen 3)

- 1. The target percentage of aggregate passing each specified sieve.
- The target percentage of <u>additional material</u> to be added by mass of the milled material.
- 3. The target percentage of <u>lime slurry</u> to be added by mass of the milled material.
- 4. The target solids content of lime slurry.
- 5. The percentage of Portland Cement to be added by mass of the milled material.
- 6. The percentage of <u>recycling agent</u> (asphalt emulsion) to be added (to 0.1%), by mass of the milled material.
- 7. The maximum water content to be added by mass of the milled material.









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Contract and Specifications (Cont.)

Specifications – Compaction

Section 404 Cold Recycle: 2021 Specials (Gen 3)

- · Re-compaction within 1-15 days
- · Prior to surface placement
 - Min. 10 days OR -
 - ≤2% MC in CIR
- Compaction Nev. T103 in backscatter
 - Soil gauge
 - Moisture and Density correlation to sand cone
 - Ave 5 locations
- 86-95% Nev. T325 Rice

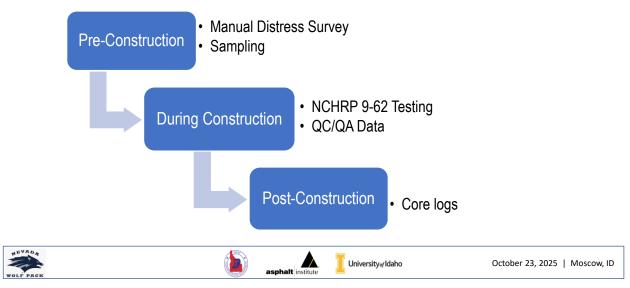








Construction Experimental Plan



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Pre-Construction: Manual Distress Survey

	tomated s Survey		Manual ss Survey	
T	Severity: Ranging from 1 to 1/8 inch	Transverse	Severity: Rangin from 1 to 1/8 inc	•
Transverse Cracks	Extent: Ranging from 40 to 200 feet	Cracks	Extent: Ranging from 5 to 55 fee	
Flushing	Low severity throughout project length	Flushing	Low severity throughout the entire project leng	
Longitudinal Cracks	Type A fatigue cracking at MP 7.0 for 30 feet	Longitudinal Cracks	Type A fatigue cracking at MP 7 for 21 feet	
Rutting	Visible rutting MP 2.5 to 5.0	major d	ing was the listress found construction	
	asphalt institut	L University₀f Idaho	0	ctober 23, 2025 Mos

SR 232 Construction (Cont.)

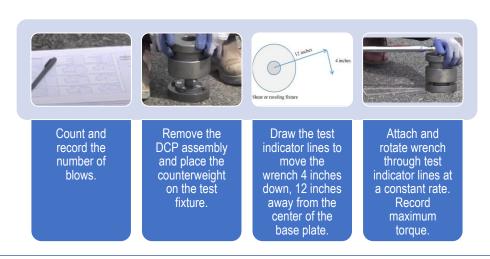
During Construction: NCHRP 9-62 (Cont.)



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SR 232 Construction (Cont.)

During Construction: NCHRP 9-62 (Cont.)



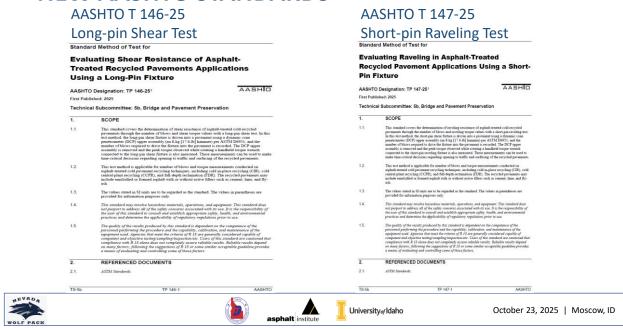
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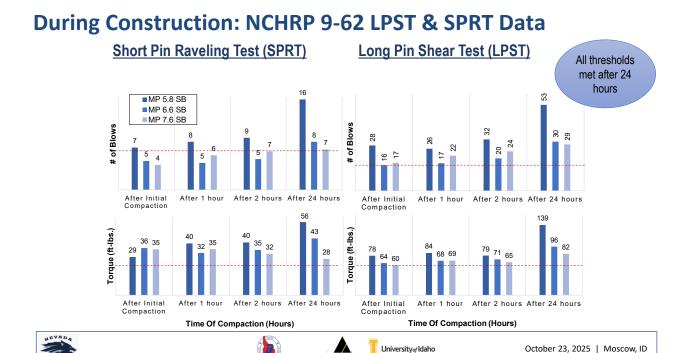




NEW AASHTO STANDARDS



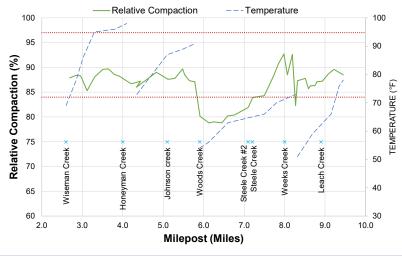
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SR 232 Construction (Cont.)

During Construction: Temperature Effect

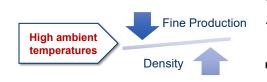




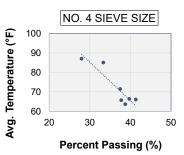
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During Construction Temperature Effect (Cont.)

- Specification limits require passing No. 4 within 30-65%.
 - Start of construction was out of specification.
 - Warmest days of construction (86°F average)







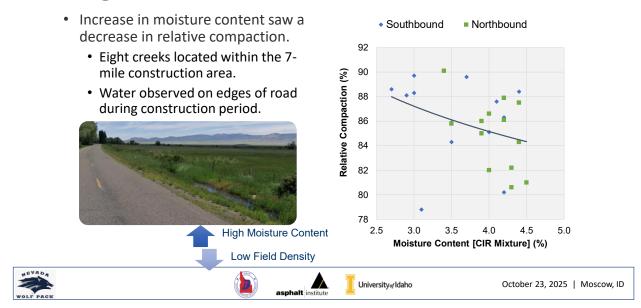








During Construction: Moisture Effect



SR 232 Construction (Cont.)

Post Construction: Core Logs

- Total of 19 cores were taken approximately 9 months after construction.
 - Original cores were taken a year prior to CIR construction.







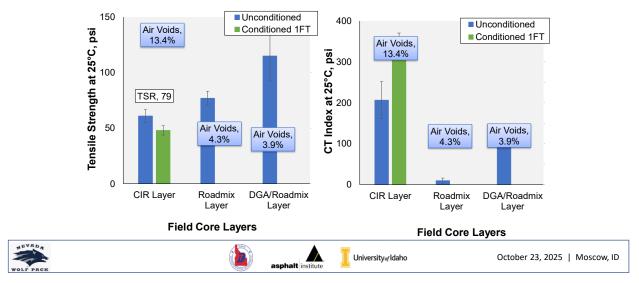






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Post Construction: CORE TESTING



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DEVELOPMENT OF A BALANCED MIX DESIGN FOR CIR FINDINGS & Recommendations

- Mix Design
 - SR 232 conditions supported the need a balanced mix design & demonstrated the benefit in Nevada.
 - Introduction of freeze thaw cycles reduced the tensile strength and TSR of each mix regardless of additive quantity or type.
 - No significant difference observed between mixtures with only lime and those with lime + cement.
 - Hveem stability did not reflect a sensitivity to additive quantities.
 - Variability between RAP sampling should be observed and limited for future studies.



DEVELOPMENT OF A BALANCED MIX DESIGN FOR CIR FINDINGS & Recommendations

- Construction & Post Evaluation
 - The CIR mat met SPRT raveling and LPST shearing thresholds at 24-hours.
 - Higher air temperatures, higher density but higher produced few fines.
 - High moisture content correlated to lower field density.
 - Improvement in target density over past specifications observed.
 - Recommend to implement and evaluate plans for a quick transition in construction operations based on air temperature.
- Collaboration & Performance
 - DOT, Industry & University Collaboration was successful
 - Project is 4 year in Service and performing very well.









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NEVADA SR232 POST-CONSTRUCTION











RESOURCES

• AARA, AASHTO, FHWA, NAPA, NCHRP, NHI, Peers, ...











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Recycling Agent



CP101 - Recommended Construction Guildelines for Standard Cold Planing (CP)

CP102 - Recommended Construction Guildelines for Micro Milling (MM)

CR101 – Recommended Construction Guidelines For Cold In-place Recycling (CIR) Using Bituminous

CR102 – Recommended Construction Guidelines For Cold Central Plant Recycling (CCPR) Using Bituminous Recycling Agents

CR201 – Recommended Mix Design Guidelines For Cold Recycling Using Bituminous Recycling CR202- Recommended Mix Design Guidelines For Cold Recycling Using Foamed (Expanded) Asphalt

CR301 – Recommended Quality Control Sampling and Testing Guidelines For Cold Recycling Using Bituminous Recycling Agents

FDR101 - Recommo Bituminous Stabilization

FDR102 - Recommended Construction Guidelines For Full Depth Reclamation (FDR) Using Cementitious Stabilization

FDR103 - Reco Stabilization

FDR201A – Recommended Mix Design Guidelines For Full Depth Reclamation (FDR) Using Emulsified Asphalt Stabilizing Agent

nded Mix Design Guidelines For Full Depth Reclamation (FDR) Using Cement or Cement Kiln Dust (CKD) Stabilizing Agent

 ${\tt FDR301-Recommended\ Quality\ Control\ Sampling\ and\ Testing\ Guidelines\ For\ Full\ Depth}$ Reclamation (FDR) Using Bituminous Stabilizing Agents

FDR302 – Recommended Quality Control Sampling and Testing Guidelines For Full Depth Reclamation (FDR) Using Cementitious Stabilizing Agents

w of Project Selection lant Pavement Recycling

TechBrief

Asphalt Pavement Recycling Technologies







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APRT IMPLEMENTATION **WORKSHOP**



SOW B.3.1

Team: Adam Hand (UNR), Jason Wielinski (Asphalt Institute)

- State agencies are at varying stages of implementing the Asphalt Pavement Recycling Technologies (APRT) in their programs.
- The APRT technologies include Hot In-place Recycling (HIR), Cold In-place Recycling (CIR), Cold Central Plant Recycling (CCPR) and Full Depth Reclamation (FDR)

Objective:

- Develop a workshop to provide State DOTs knowledge on how to get started and/or move forward with implementation of APRT technologies
 - Based on case studies, example specifications, review of existing standards, etc.
- Modular based so agencies can select which technologies they need information

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AIEI ASPHALT PAVEMENT RECYCLING TECHNOLOGIES (APRT) **IMPLEMENTATION WORKSHOPS**

The **free workshops** will be delivered in-person or virtually using Microsoft Teams or any other meeting platform accepted by a State Department of Transportation (DOT).

DESCRIPTION

This federal Highway Administration (FHWA) workshop(s) will provide State DOTs with knowledge on how to get started and/or more forward with impermentation of asphalt pawment recycling technologies (APRT) based on in depth case studies from key State DOWS. Workshops are customized to a State DOTs current situation with its APRT implementation program. APRT includes cold in-place recycling, cold central plant recycling, full depth reclamation with applial or center, and not be in place recycling.

- a. The overall APRT and their unique benefits.
- c. Positive practices and lessons learned by key State DOTs.

Workshops will focus on the APRT of interest to the DOT for implementation that were developed and conducted based on in-depth case studies of key State DOTs.

There are 4 APRT workshop modules, one for each APRT. Each APRT module is 2 hours. DOTs can select 1 or up to 4 APRT modules. The workshop can be delivered over the course of one or multiple days.

TARGET AUDIENCE

The successful implementation of APRT will need to be a team effort. Thus, the target audiences for the workshop are managers and practitioners interested in the implementation of APRT from State DOTs, industry, academia, and consultants. This involves participants from various offices of a State DOT, such as materials, pavement design, construction, and pavement management.

OUTCOMES

Upon completion of a workshop, participants will be

- · Understand the why and overall benefits of APRT(s).
- Recognize the planning and coordination effort associated with selection, design, construction and quality assurance for APRT.
- Identify the tasks needed for effective development and implementation of APRT program(s).
- Recognize successful key State DOTs practices and experiences related to APRT.
- Recognize available external technical information and support with APRT.



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FOR MORE INFORMATION:

Contact Timothy Aschenbrener to timothy.aschenbrener⊕dot.gov



CIR/CCPR QUALITY ASSURANCE WORKSHOP



SOW B.3.2

Team: Jason Wielinski, Dave Johnson (Asphalt Institute), Adam Hand (UNR) Why:

- CIR/CCPR Technologies are like HMA, however construction and materials properties require different QA procedures and analysis.
- Agencies new to CIR/CCPR may not be familiar with these materials, specifications or processes Objective:
 - Develop a workshop that demonstrates quality assurance practices and procedures for agencies implementing CIR and CCPR in their programs
 - Workshop is targeted for 4-6 hours in length
 - Explains example specifications and standards related to CIR/CCPR

SOW B.3.3 is the deployment of the workshop

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THANK YOU!

- Adam Hand, PhD, PE_{IN, NV, NM, OR}
- Professor / Consultant
- UNR / Reno, Nevada
- (775) 742-6540
- adamhand@unr.edu











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Q&A?





Extending Asphalt Pavement Life: From Rejuvenation to Reflective Crack Mitigation

65th Annual Idaho Asphalt Conference

Michael Vrtis, Ph.D., P.E | Assistant MnROAD Operations Engineer





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Overview

- Study #1 Spray Applied Rejuvenators
 - · National Road Research Alliance
 - Experiment Setup and Products
 - · Results and Takeaways
- Study #2 Reflective Cracking Challenge
 - Minnesota Road Research Facility (MnROAD)
 - Field Performance Results
 - Laboratory Performance Testing
 - MnROAD Low-Volume Road Test Sections
 - Takeaways



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NRRA Spray Rejuvenator Field Sections -**Summary of Research Findings**

Michael Vrtis, Ph.D., P.E. (MN) | Assistant MnROAD Operations Engineer



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National Road Research Alliance

TPF-5(466) - Fee Structure / year (five years)

- Phase-1 complete (5 yr) Now into Phase-2 (year 3/5)
- 14 Full Agency Commitments (yellow)
 - \$75K /\$150K Annual Commitment
 - 12 States, Illinois Tollway, LRRB
 - FHWA is also a contributing partner

2 ICT Commitments (Green)

- \$25K (ICT Team only Veta Efforts)
- GA and NY

~85+ Associate membership

- 2K/year Associations, Industry, Consultants, Universities
- Upper Great Plains Transportation Institute

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What is a Spray Rejuvenator?

- Spray on Rejuvenators (SOR)
 - Preventative Maintenance Treatment for Asphalt Surfaces
 - · Intended to:
 - · Restore binder properties
 - Delay surface aging
 - · Originally, developed in 1970's
 - · Higher interest lately due:
 - · increased PM emphasis
 - · bio- based products



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Project Objectives

- Despite long history, questions remain:
 - 1. What do SORs do to surface asphalt?
 - Short-term and long-term
 - 2. How long does it last?
 - 3. How can it be measured for QA/QC and payment?
- NRRA put a call for products marketed as "Spray on Rejuvenators" in 2020-2021
 - Products voluntarily submitted by mfg./ product reps.
 - No screening or selection into study by MnDOT or NRRA



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Products in Study

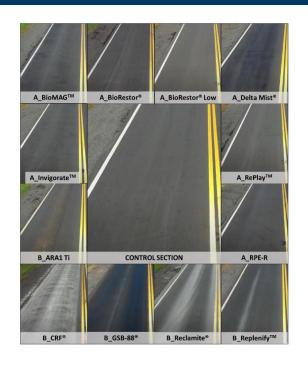
Group	SORs	Composition			
	BioMAG TM				
	BioRestor®				
Group A	BioRestor® Low VOC	Bio-based			
(No fine	Delta Mist®	DIO-Dasea			
aggregate)	Invigorate TM				
	RePlay TM				
	RPE-R				
	ARA1 Ti				
Group B	CRF®	D (1 1 1			
(Fine	GSB-88®	Petroleum-based			
aggregate)	Reclamite®				
	Replenify TM				



Application of SOR on an asphalt pavement Field Application Video

SOR: Spray-on-rejuvenators

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Products Included in Study

 Different aesthetic properties of each treatment



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Test Sections

- All 12 treatments applied in Summer of 2021 primarily middle of July
- All 12 treatments applied in 3 locations:
 - MnROAD Low-Volume Road over PG58S-28 paved 2 in May 2021 50'
 - MnROAD Low-Volume Road over PG58H-34 paved 2 in May 2021 50'
 - 15th Street in St. Michael, MN over PG58H-34 paved in 2020 500'
- Multiple controls at each location



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Additional Testing/Monitoring

- MnROAD Team Conducted:
 - · 860+ Sand Patch Tests
 - 430+ DFT Tests
 - Annual Skid Trailer
 - Albedo
 - Drone video MnRoad Research YouTube
 - Pathways van (ruts, cracks, and ride)
 - 1800+ cores



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Research Teams and Contracts

NRRA Contract with NCAT (PI=Dr. Raguel Moraes)



- · Refined scope to focus on extracted and recovered binder testing from field cores taken at 1 month, 12 month, and 24 months post application
- Chemical and Rheological Characterization
- · Final Report under Review



- Mn Local Road Research Board (LRRB) with MSU (PI=Dr. Emin Kutay)
 - · Refined scope to focus on construction monitoring and field performance
 - · Deliverables geared toward "county engineer"
 - · Quick takeaways with benefits and concerns summarized
 - Final Report published



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NRRA and National Center for Asphalt Technology



Raquel Moraes



Amir Jafarmilajerdi, Ph.D. candidate



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Mn Local Road Research Board and Michigan State University



Presented by Tanzila Islam, m.sc. Graduate Research Assistant Michigan State University





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Dr. M. Emin Kutay, Ph.D., P.E. Professor and PI Michigan State University

Dr. Syed Waqar Haider, Ph.D., P.E. Associate Professor and Co-PI Michigan State University

Dr. Bora Cetin, Ph.D. Associate Professor and Co-PI



Michigan State University

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MSU Results – Friction / Macro Texture

- Field testing using:
 - Dynamic Friction Tester
 - Skid Trailer
 - Sand Patch

Skid Resistance and Abrasion

> British Pendulum Testing (before and after the abrasion)

To quantify change in friction







MICHIGAN STAT



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- Slight reduction in friction in 1 month testing
- Friction returned in 1 year testing
- *1 Test section impacted by unexpected rain
- At no point in project was there a safety risk to travelling public from application of SORs
- Initial roadway condition is important!
 - Not recommended for roads with poor initial friction or high friction demand

NCAT Results

- All testing on extracted/ recovered binder from MnROAD cores (top 9mm of core)
 - w/ manufacturer recommended solvent
- Chemical analysis Included:
 - Gas Chromatograph/Mass Spectrometry
 - SARA Analysis
 - Fourier-Transform Infrared Spectroscopy by Attenuated Total Reflectance



Image created using Google Gemini *Imagen 3; prompt = draw chemist* dressed as construction working fixing a road

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NCAT Results –Chemistry



Image created using Google Gemini Imagen 3;

	Characteristic								
Product	Petroleum Asphalt	Triglyceride Fatty Acid	Fatty Acid Ester	Carrier	Surfactant	Glycol Ether	Phthalate	Polymer	
Product 1			Х	X				Χ	
Product 2			Х		X			Х	
Product 3			X	Х				X	
Product 4			Х					Χ	
Product 5, Part A		X				Х			
Product 5, Part B		X		X					
Product 6		X							
Product 7		Х			X				
Product 8, Part A							X	Х	
Product 8, Part B	X	X							
Product 9	X								
Product 10	X								
Product 11	X								
Product 12	X								

Gas Chromatograph/Mass Spectrometry Results

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NCAT Results –Chemistry

• SARA Results:

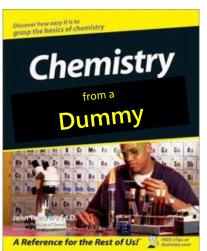
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- Saturates, Aromatics, Resins, and Asphaltenes
- Asphaltenes are bad; (heavy black long hydrocarbons)
- Maltenes are good (Saturates, Aromatics, and Resins)
- Think fruit loops with chocolate marshmallows



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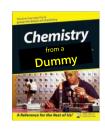


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NCAT Results – Chemistry

 As asphalt ages ratio of asphaltenes to maltenes increases (more bad stuff to good stuff)





Original asphalt

Aged asphalt

Image created using Google Gemini Imagen 3;

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NCAT Results - Summary

- Different solvents and analysis methodologies needed for different products
- "Binder base type (chemistry) strongly influences SOR performance"
 - PG58H-34 has higher resistance to aging thus SORs showed limited improvement
 - PG58S-28 showed improvement from all SORs
- Different types have different rejuvenating mechanisms
 - Petroleum-based products directly add maltenes to restore balance
 - Bio-based products disrupt conversion of maltenes to asphaltenes



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Image created using Google Gemini Imagen 3;

Summary from Upcoming NCAT Newsletter

- Spray-On Rejuvenators at MnROAD: Two Years of Real-World Lessons
- Findings That You Can Use (1-7)
 - 1. Effectiveness is product specific, not category driven
 - 2. Monitor application by residual oil mass
 - 3. Expect early friction drop and plan for it
 - 4. Chemistry and rheology together to tell full story
 - 5. Binder type influences sensitivity to treatment
 - 6. Product chemistry can confound chemical metrics
 - 7. Short-term aging is confirmation spec not gate



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Summary from Upcoming NCAT Newsletter

- How To Use This on Your Next Project
 - Specify residual oil mass
 - Use 2 Stage Acceptance
 - · Plan for safety
 - · Match product to site
 - Interpret Chemical indices with awareness of solvent effects; Avoid over-emphasis on SARA fractionation and use complimentary indicators (FTIR etc.)

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Summary from Upcoming NCAT Newsletter

Bottom Line=

 Spray-on rejuvenators can extend surface life, but success depends on matching the product and retained dose to the pavement and verifying performance over time. Focus specs on residual oil mass, plan for early friction management, and evaluate chemical and rheological behavior together. With these steps, agencies can turn a promising treatment into a reliable preservation tool.

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Michael Vrtis, Ph.D., P.E | Assistant MnROAD Operations Engineer





Sponsor Recognition

MnROAD Reflective Cracking Challenge

- Construction Support/ Mix Design
 - MnROAD / NCAT Additive Group (NY participation)
 - · Companion Test Sections at NCAT Test Track in Auburn, AL
- Construction Funding and Monitoring = MnDOT
- NRRA research contract awarded to University of New Hampshire
 - Dr. Ben Bowers is sub-contractor for LCA Companion test sections on NCAT Test Track (2021) and in Missouri (2023)
 - Companion test sections in Missouri "boot-heel"; Dr. Bill Buttlar (MCTI)





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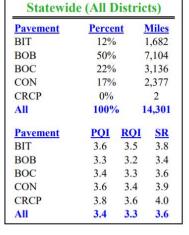
2022 MnROAD Reflective Cracking Challenge

 Experiment designed to better match MnROAD research to MnDOT network applications

BOB = bituminous over bituminous ~50% network



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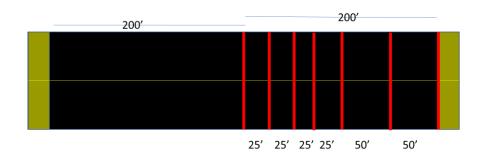
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MnROAD Reflective Cracking Challenge

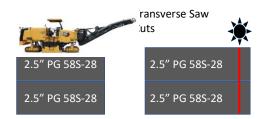




- Paved 450' per section
- 200' reflective cracking
- 200' conventional

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MnROAD Reflective Cracking Challenge



Milled surface
1.5" PG 58S-28
2.5" PG 58S-28

2.0" Unique Surface 1.5" PG 58S-28 2.5" PG 58S-28

Test Sections were constructed in 2022

Saw-cutting

- Full depth (5") saw cuts were made 24' through travel lanes
- Cuts were minimally cleaned with leaf blower and wire
- No cleaning after milling





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Surface HMA Mix Details

- 10 Sections with differing surface HMA
 - o Controls
 - 1. PG 58H -34 (modified) 2239
 - 2. PG 58S -28 (unmodified) 2230
 - 3. PG ~49 -34 (unmodified) 2238
 - Additive Sections
 - 4. Aramid Fiber 1 w/ PG 58H -34 (modified) 2233
 - 5. Aramid Fiber 2 w/ PG 58H -34 (modified) 2234
 - 6. Dry Plastic Additive w/ PG ~49 -34 2236
 - 7. Dry Rubber Additive w/ PG ~49 -34 2237
 - 8. Wet Plastic Additive 2232 w/ PG 52-34 from Mathy
 - 9. Wet Rubber Additive 2235
 - Super Pave 5.0
 10. PG 58V -34 (modified) (NRRA) 2231



- All mixes contain
 - MnDOT Traffic Level 5 (10<30 mESALS)
 - Superpave Gyratory BMD
 - ¾" Max Agg (SP 12.5mm)
 - 20% RAP

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MnROAD Additive Group Surface Mix Details

Additive Type/ Mix ID	Additive Manufacturer	Dosage Rates
Dry Rubber	Liberty Inc.	12% SmartMix by weight of the binder
Dry Plastic	Avangard	0.5% LLDPE pellets by weight of aggregate
Wet Rubber	Entech	10% by weight of the binder
Forta Fiber	Forta Corp.	1 lb. fiber per 1 ton of asphalt mix
ACE Fiber	Surface Tech	3.4 ounces per ton of mix
Wet Plastic	Dow chemicals	1.0% LLDPE plastic & 1.5% Elvaloy

^{*}State on Minnesota does not endorse any products

Additives selected by MnROAD NCAT Additive Group Study Sponsor Agencies Companion sections with same additives built at NCAT Test Track in 2021

Longitudinal Joint Treatment

• J-Band applied on centerline and longitudinal shoulder joint

 Driving lane paved 13' wide with 12' lane to push longitudinal joint away from traffic

• J-Band donated application for this effort



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Contractor and HMA Plant

- Great collaboration/ buy-in from paving contractor (C.S. McCrossan) and HMA plant (Martin Marietta – Elk River Plant)
- Additive Group Mix was procured separately from MnROAD I-94 paving contract
 - (formerly Commercial Asphalt)
 - Allowed for early collaboration with MnROAD, plant (MM), and NCAT

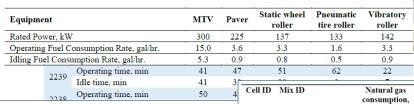






NCAT Testing and Monitoring

- NCAT (Buzz and Nathan) at HMA plant (40 minutes from MnROAD)
 - Dialing in mix
 - Plant energy usage
- Suri at MnROAD



 Cell ID
 Mix ID
 Natural gas consumption, ft³/sh.ton
 Electricity, kWh/sh.ton

 2239
 Control (PG 58H-34)
 192.0
 2.17

 2238
 Control (PG 58S-28)
 187.8
 2.17

 2237
 Dry Rubber
 196.0
 2.17



Traffic

- Test Sections were opened to traffic in Fall 2022
- Weigh in Motion (WIM) immediately follow test sections

 *Traffic not on test sections for 1 month in summer 2023 and 2024 for concrete test cell reconstruction

	CARS	TRUCKS	ESALS	
Driving Lane	5,622,079	2,790,193	2,027,203	
Passing Lane	6,936,824	1,851,506	827,101	



*Courtesy of Dr. Joseph Podolsky

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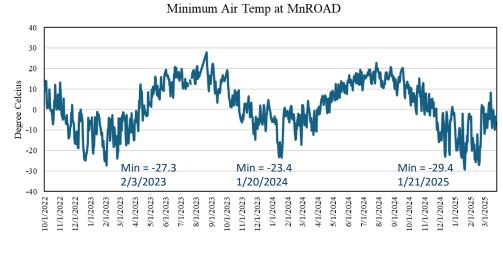
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Winter Temperature Summary

- Mild winter
 2023 -2024
- Average MN winter 2024-2025

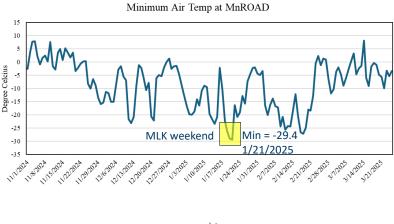




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Winter 2024/2025 Action

• No cracks in any sections prior to MLK weekend 2025

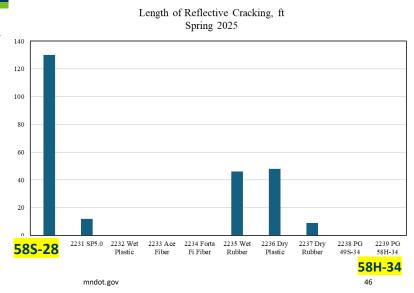


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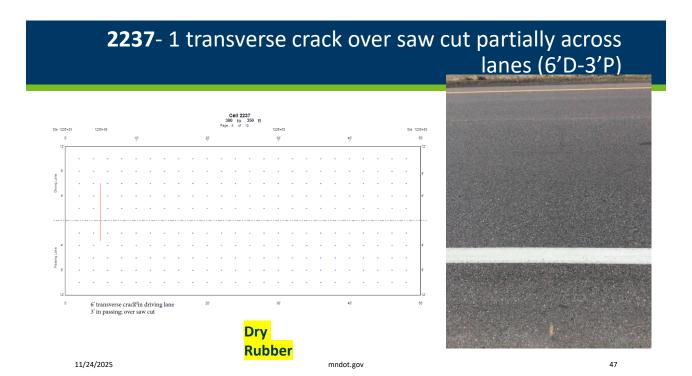
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Cracking Results through Spring 2025

- No cracking through 12/2024
- 1st cracks occurred over MLK weekend
- All cracks over saw-cuts
- 168' of total saw-cuts in each section
- Continued monitoring thru 2028



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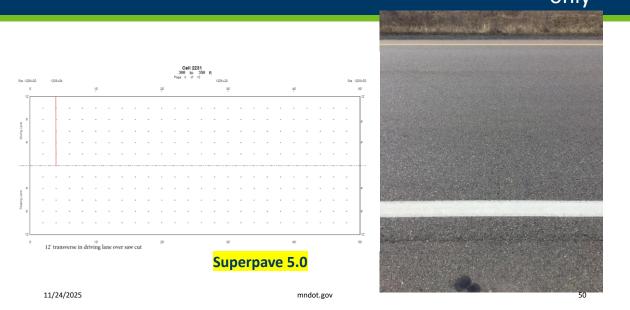
2236- 4 transverse cracks over saw cut; 1 of 4 is 24'; 3 of 4 are partial mainly in Driving



- 4 transverse cracks over saw cut; 0 of 4 is 24'; 4 of 4 are partial mainly in Driving Lane

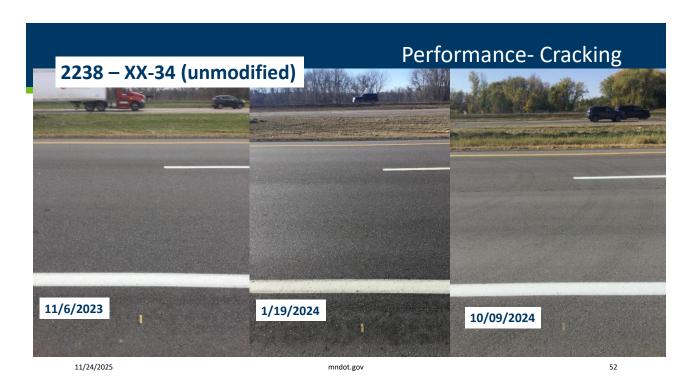


- 1 transverse crack over saw cut; 12' in Driving lane only

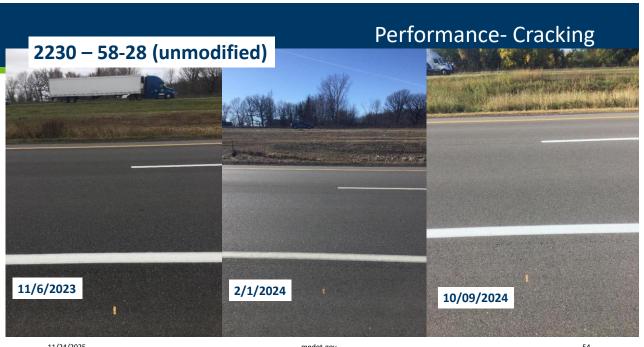


- 6 transverse cracks over saw cut; 4 of 6 is 24'; 1 of 6 is 23'; 1 partial mainly in Driving Lane







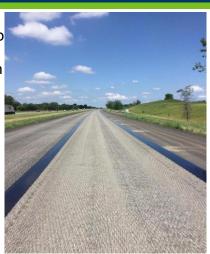


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Longitudinal Joint Treatment

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- Driving lane paved 13' wide with 12' lane to push traffic
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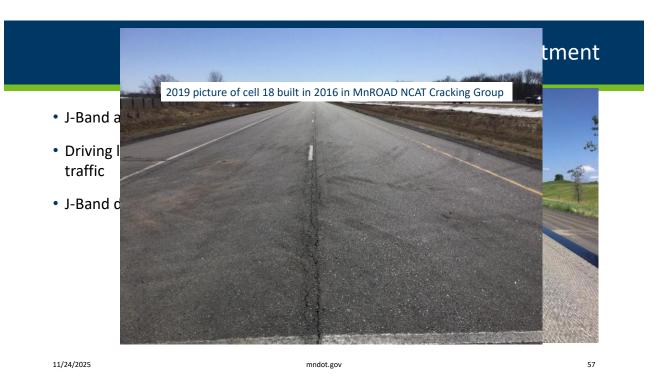


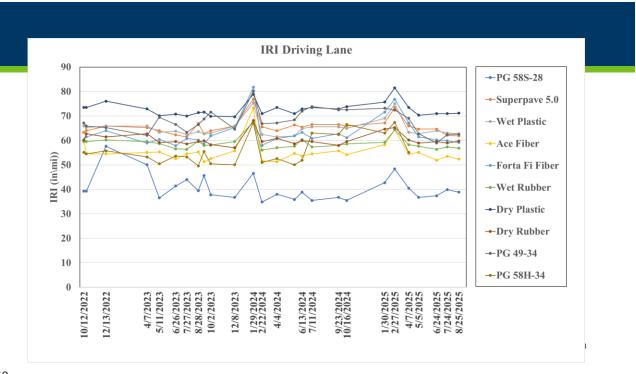


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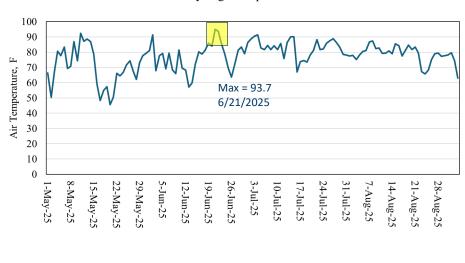






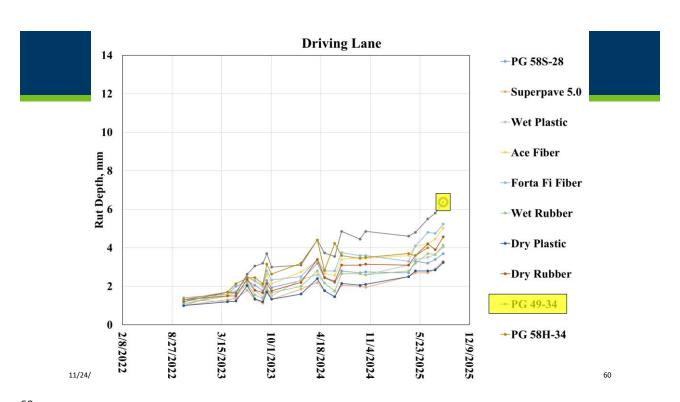
High Temperatures Summer 2025

Daily High Temperature



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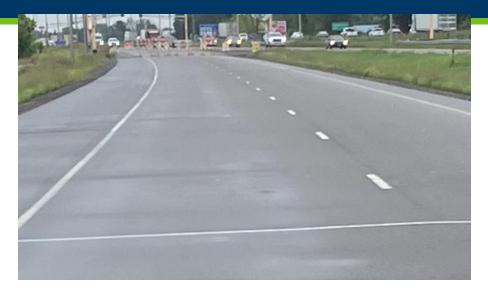




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Performance - Rutting



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Laboratory Testing List

- Low Temperature = Disc-shaped Compact Test (DCT), Simplified Wedge Splitting (SWST), Uniaxial Thermal Stress and Strain (UTSST), Semi-circular Bend (SCB), Binder and Mix Bending Beam Rheometer (BBR), PG Grading
- Design Inputs = Dynamic Modulus (E*), Direct Tension Cyclic Fatigue (DTCF), Texas Overlay Tester (TOT)
- NRRA Agency = Illinois DOT i-FIT; MnDOT Hamburg, IDEAL CT, & IDEAL RT,





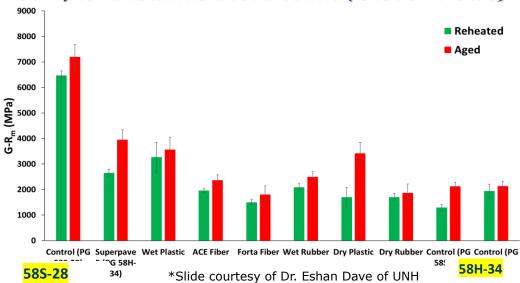
 Testing focused on both fundamental material properties, design inputs, and QC/ production testing

Images created using Google Gemini: Imagen 3;

11/24/2025 mndot.gov 63

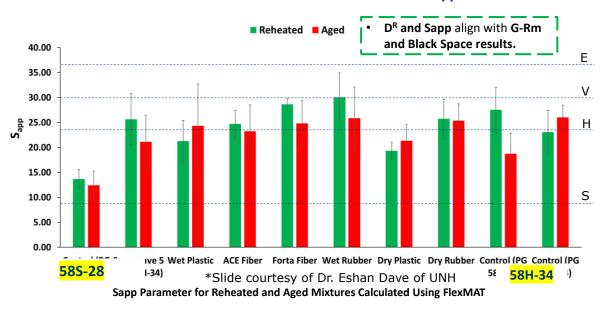
63

Complex Modulus Test Results (Glover-Rowe)



Glover-Rowe (G-Rm) Parameters for Reheated (Green) and Aged (Red) Mixtures at 21.1°C and 5 Hz

Cyclic Fatigue Test Results (S_{app})



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Low-Volume Road Reflective Cracking Challenge

- 4 test sections constructed in 2023 on MnROAD Low-Volume Road (LVR)
- Bottom lift paved with 58S-28 low traffic mix
- Surface mixes tested:

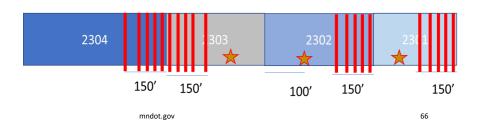
1. PG 58S-28

2. PG 58H-34

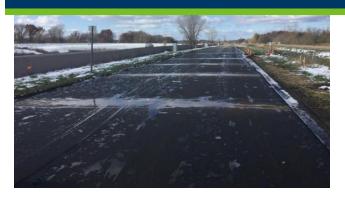
3. PG 58S-28 + 0.5% binder

4. PG 58H-34 + 0.5% binder





Construction of LVR Reflective Cracking Challenge



1st lift paved 10/30/2023 Saw-cuts on 10/31/2023 2nd lift paved 11/1/2023

11/24/2025

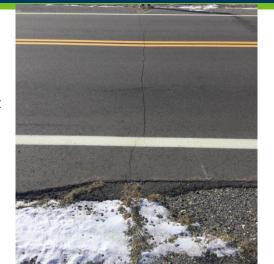
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Early Results from LVR Reflective Cracking Challenge

- No cracks observed over saw- cut
- · Shoulders matter!
- But several cracks occurred in section that had existing shoulders with cracks

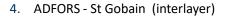


11/24/2025

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Products in Study

- 1. SuperFiber by Hi-Tech
- 2. Renucore by Certainteed
- 3. Genable Pavement by Universal Matter









All test sections using MnDOT traffic level 3 mix and PG58S-28 binder

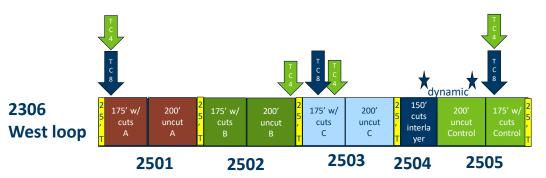
*MnDOT does not endorse products; products included in study on voluntary basis

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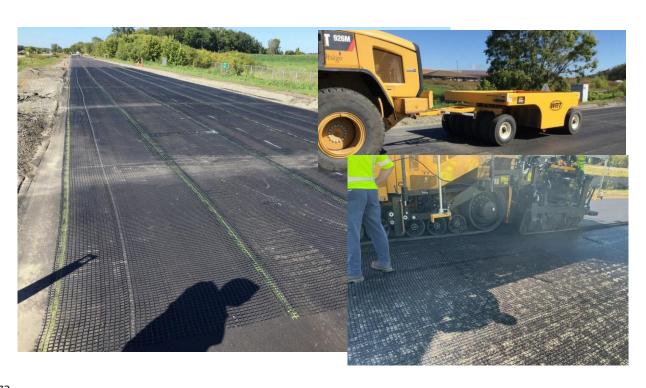
Working Layout

- TC8 = Thermocouple tree 6' deep
- TC4 = Thermocouple in 4"HMA



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Reflective Cracking - Summary and Takeaways

- Polymer modified binder showing improved resistance to low-temperature cracking
- Successful construction with various HMA additives
- Environmental characterization underway
- Continued performance monitoring thru 2028

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 Correlation between lab tests and field performance

Images created using Google Gemini: Imagen 3;



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11/24/2025

Resources

- https://www.dot.state.mn.us/mnroad/ General MnROAD
- https://www.dot.state.mn.us/mnroad/nrra/index.html General NRRA
- MnRoad Research YouTube
- https://www.dot.state.mn.us/mnroad/nrra/structureteams/flexible/index.html - MRCC Project page

Reflective cracking

- Continued Monitoring of Original I-94 Westbound Asphalt Overlay Sections and Use of Cracking and Performance Data MRCC Project (2023) (co-sponsored with Rigid Team)
- MnROAD Reflective Cracking Challenge (2021)
- <u>Developing Best Practices for Rehabilitation of Concrete with Hot Mix Asphalt (HMA) Overlays related</u> to <u>Density and Reflective Cracking (2017)</u>

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Thank You!

Michael Vrtis

Michael.vrtis@state.mn.us 612-360-9852

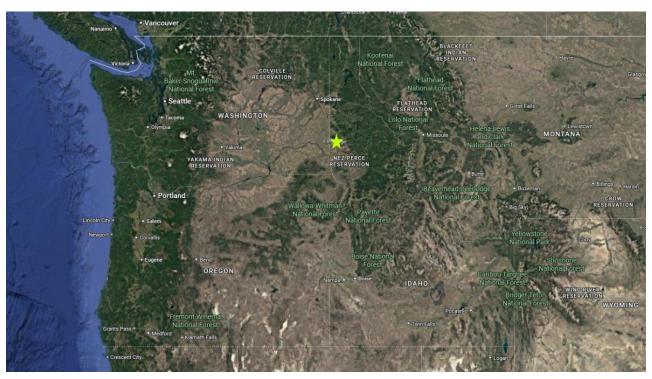


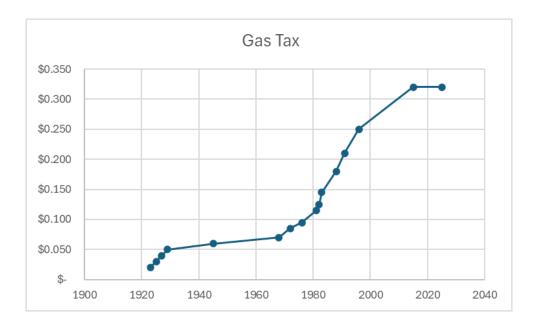
Moscow Pavement Preservation Asphalt Rubber Chip

October 23, 2025 Idaho Asphalt Conference Tyler Palmer, Public Works Director – Deputy City Administrator



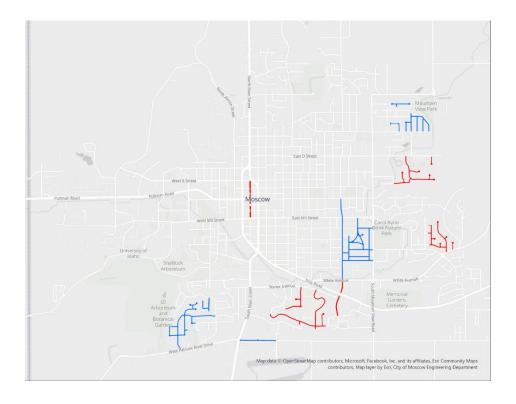
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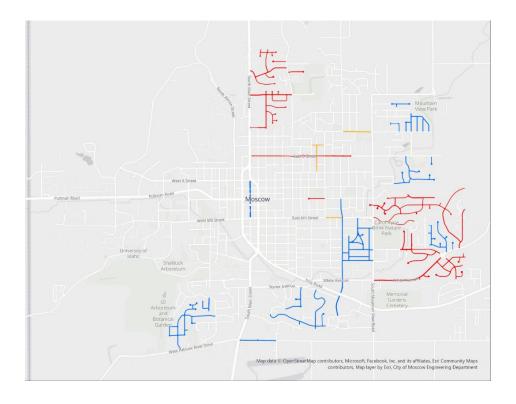


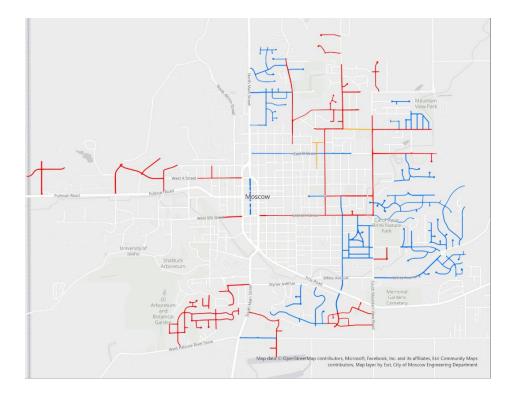


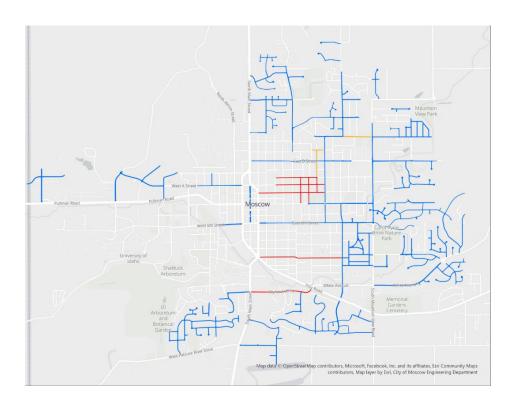


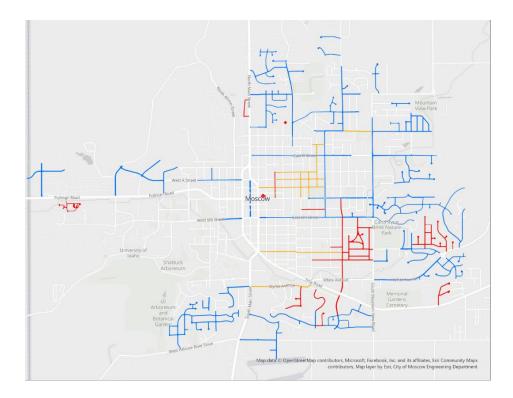


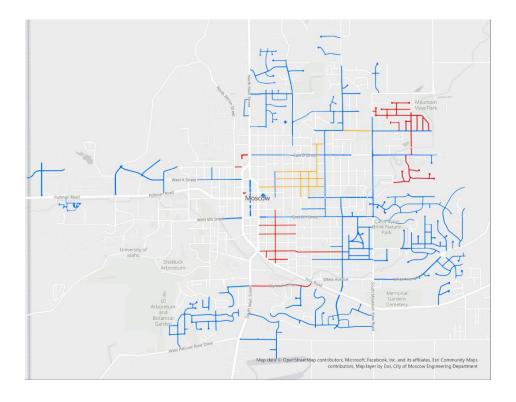


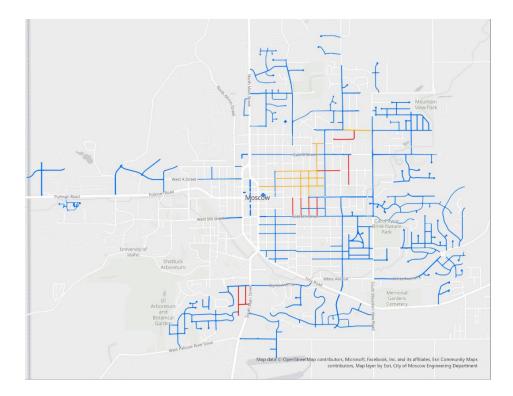


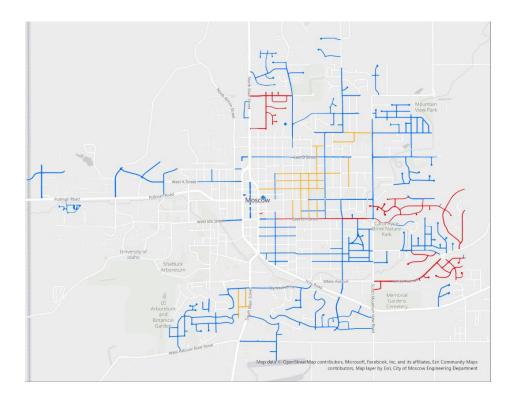


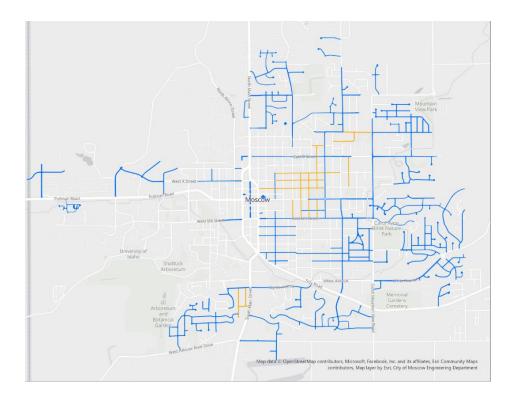












Field Blended Binders

A blend of any combination of PG Asphalt,

Crumb Rubber Modifier, Polymer, and other modifiers.

Components blended with mobile equipment in the field or at remote location prior to application on the roadway.

Field blend binders can be custom designed to meet climatic, traffic loading, and other unique field conditions.



Asphalt Rubber Blend Site



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Why modify asphalt?

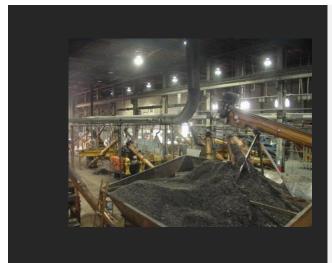
Unmodified asphalt can be sensitive to temperature variations or adverse conditions such as vehicle loading.

Brittle in the Cold resulting in thermal cracking.

Soft in the Heat resulting in rutting, flushing, and surface deformation at elevated temperatures.

Rubber can use up to 600 recycled tires per lane mile at a 12" width





Tires Recycling



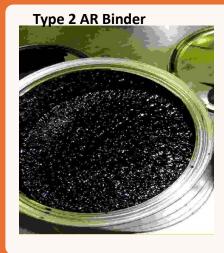
Multistage grinding to create ground/graded rubber

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Binder Comparison





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Application:

Specialized Equipment

Uses units equipped with agitation, heating, and CRC (Computerized Rate Control) systems.

• High Application Temperature

Applied at elevated temperatures exceeding 350°F.

• Increased Application Rates

Utilized at higher application rates and asphalt residuals compared to most binders.

Water-Free System



No water present in the system, ensuring optimal binder performance.

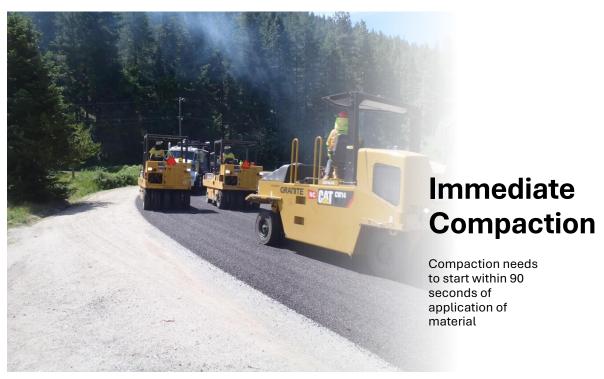
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Wet Pavement Prior to Application





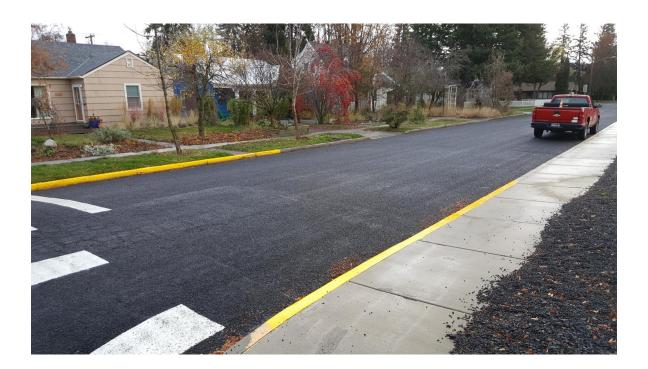








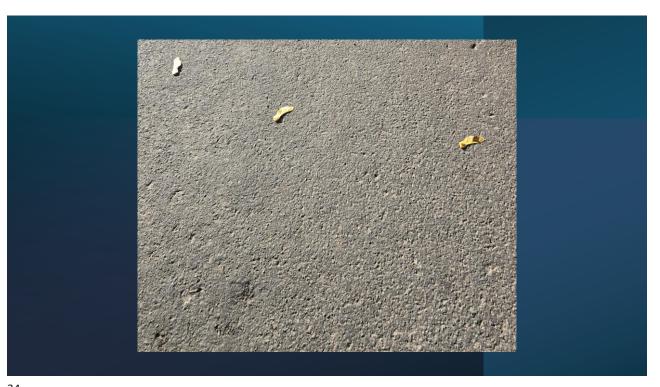




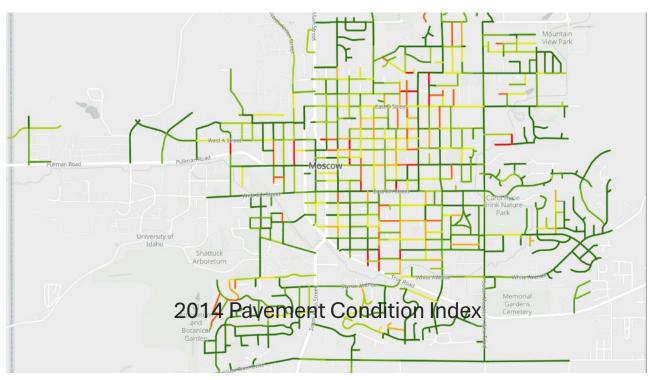


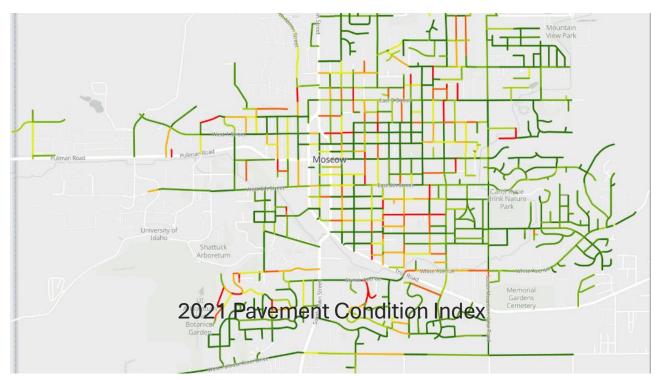


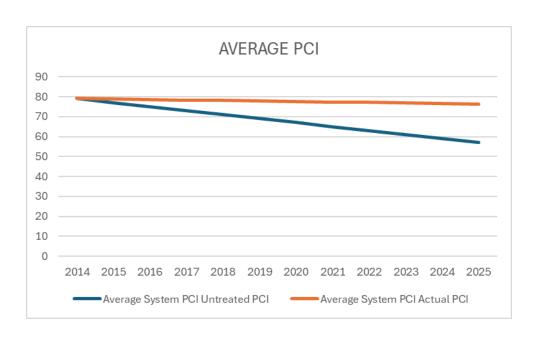














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