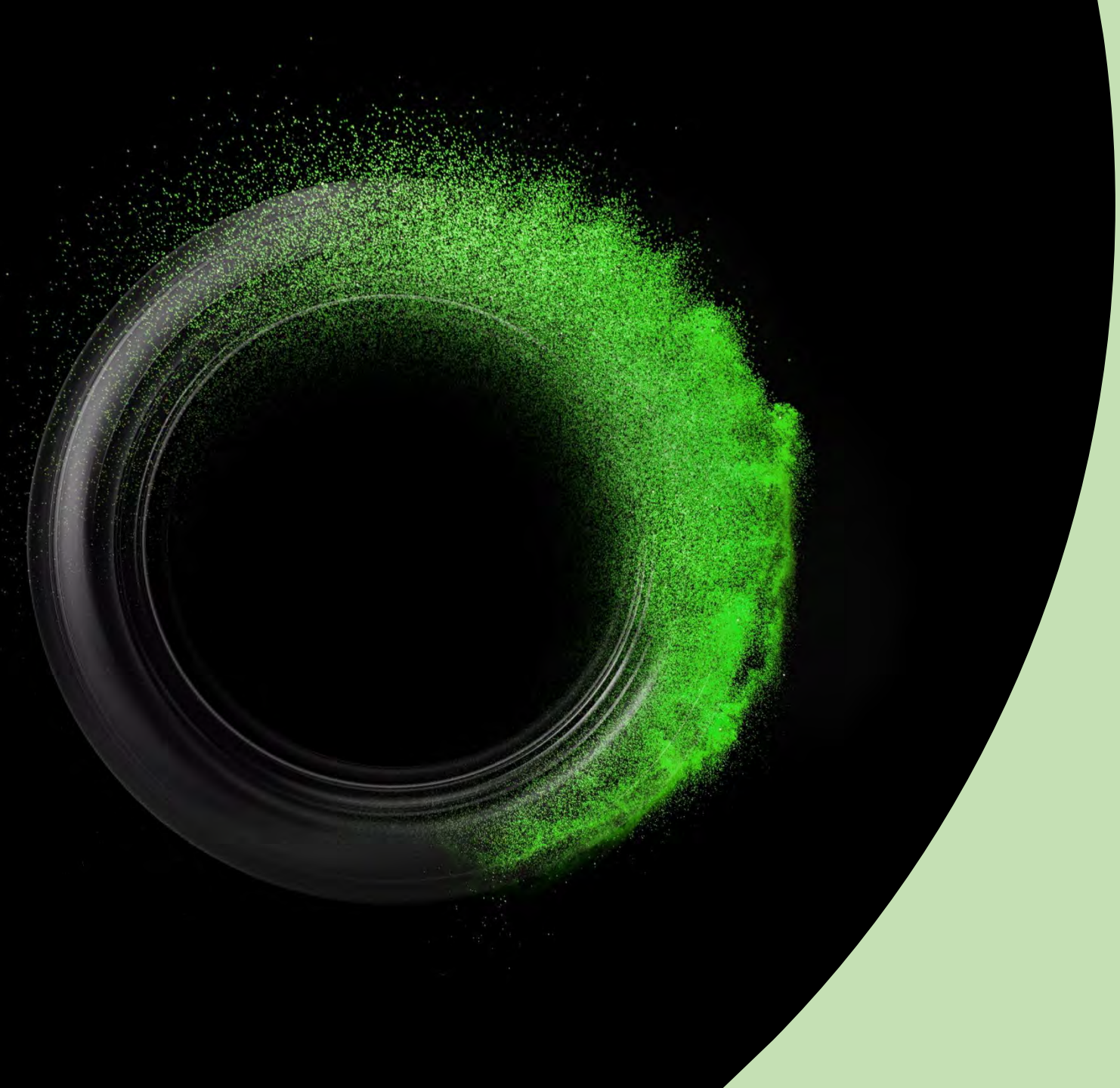

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ENGINEERED CRUMB RUBBER AND LOWER COST, SUSTAINABLE ASPHALT PAVEMENTS

PENNSYLVANIA ASPHALT PAVEMENT ASSOCIATION ANNUAL MEETING

1/17/24

REDMOND (RED) CLARK, PhD
ASPHALT PLUS, LLC

TOPICS FOR DISCUSSION TODAY

- WHAT ARE SUSTAINABLE ROADS AND MIXES?
- ENVIRONMENTAL AND ECONOMIC CHANGE IMPACTING THE INDUSTRY
- NEW ENGINEERED CRUMB RUBBER PROCESSES ARE A SUSTAINABILITY TOOL
  - ECR HISTORY AND FUNCTIONS
  - ECR IN LAB, MIX DESIGNS
  - ECR IN THE FIELD
  - ECR VALUE PROPOSITIONS
  - INDUSTRY ACCEPTANCE, SPECIFICATIONS
  - ECR AND EPDs, LCAs

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“SUSTAINABLE” ASPHALT PAVEMENTS

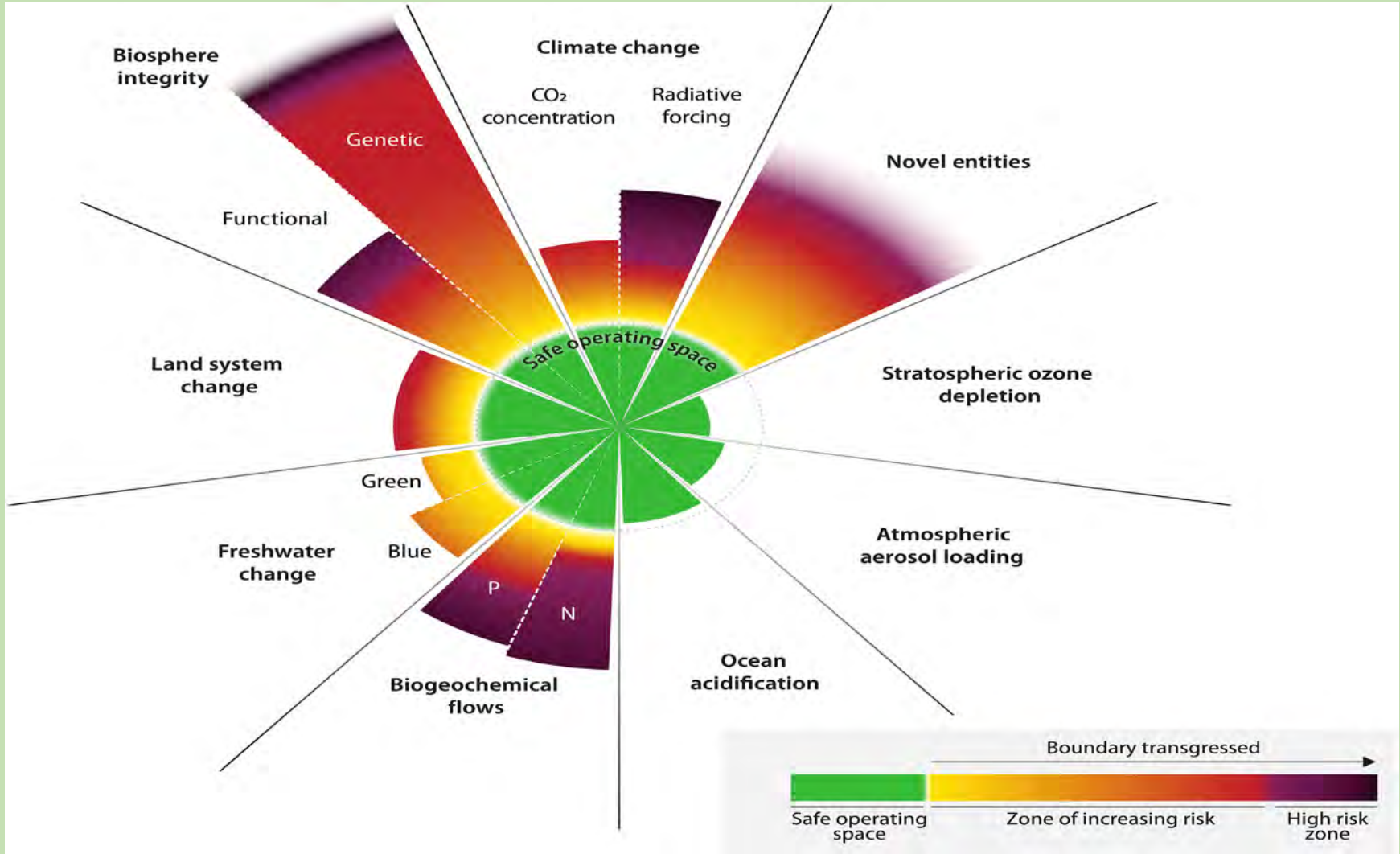
- SUSTAINABLE MIX
  - “CRADLE TO GATE”
  - EPDs LAY OUT THE MIX ENVIRONMENTAL FOOTPRINT
  - REDUCED ENVIRONMENTAL FOOTPRINT
    - EFFICIENT QUARRYING, SHORTER TRANSPORT
    - BETTER STOCKPILE MANAGEMENT
    - LOWER PLANT TEMPERATURES
    - MAXIMUM RECYCLING CONTENT
    - MINIMUM VIRGIN BINDER CONTENT
- SUSTAINABLE ROADS
  - “CRADLE TO REPAVE”
  - EPDs VS LCA
  - REDUCED ENVIRONMENTAL FOOTPRINT
    - PAVEMENT DESIGN AND MATERIALS
      - MORE SUSTAINABLE MIXES
      - IMPROVED LAYDOWN PROCESS
      - MORE DURABLE ROAD
- DESTINATION POINT: ROAD DURABILITY MORE IMPACTFUL THAN MIX SUSTAINABILITY ALONE

WHY SHOULD SUSTAINABILITY BE AN INDUSTRY FOCUS?

ENVIRONMENTAL CASE

BUSINESS CASE

GROWING PRESSURES ON GLOBAL ECOSYSTEM SERVICES = MORE DIFFICULT BUSINESS ENVIRONMENT



ROAD SUSTAINABILITY DRIVERS

ENVIRONMENTAL CASE

- PLANETARY ECOSYSTEM SERVICES MAXING OUT
- EVIDENCE AT HAND:
  - GLOBAL TRASH GYRES
  - MICROPLASTICS
  - CHANGES IN OCEANIC, ATMOSPHERIC CHEMISTRY, TEMPERATURE
- 8 BILLION PEOPLE ON THE PLANET, GOING FOR 9
  - 1.5 BILLION IN ADVANCED ECONOMIES
  - 6.5 BILLION IN POOR AND DEVELOPING ECONOMIES
- CELL PHONES AND LIVING STANDARDS
- 8 BILLION IN ADV. ECONOMIES = 4.5 PLANETS

BUSINESS CASE

- FOLLOW THE MONEY…
- INCREASING PRODUCER RISK
  - RAW MATERIALS COST/INSTABILITY ⇧
  - COSTS OF COMPLIANCE ⇧
- INCREASING PUBLIC SECTOR RISKS
  - ACCELERATING INFRASTRUCTURE COSTS
    - DEFERRED MAINTENANCE
    - REGULATORY BURDEN
    - RAW MATERIAL COSTS
  - REVENUE SECURITY
  - FEDERAL AND STATE DEFICITS AND DEBT
- SUSTAINABLE ROADS CAN REDUCE OR OFFSET SOME OF THESE RISKS

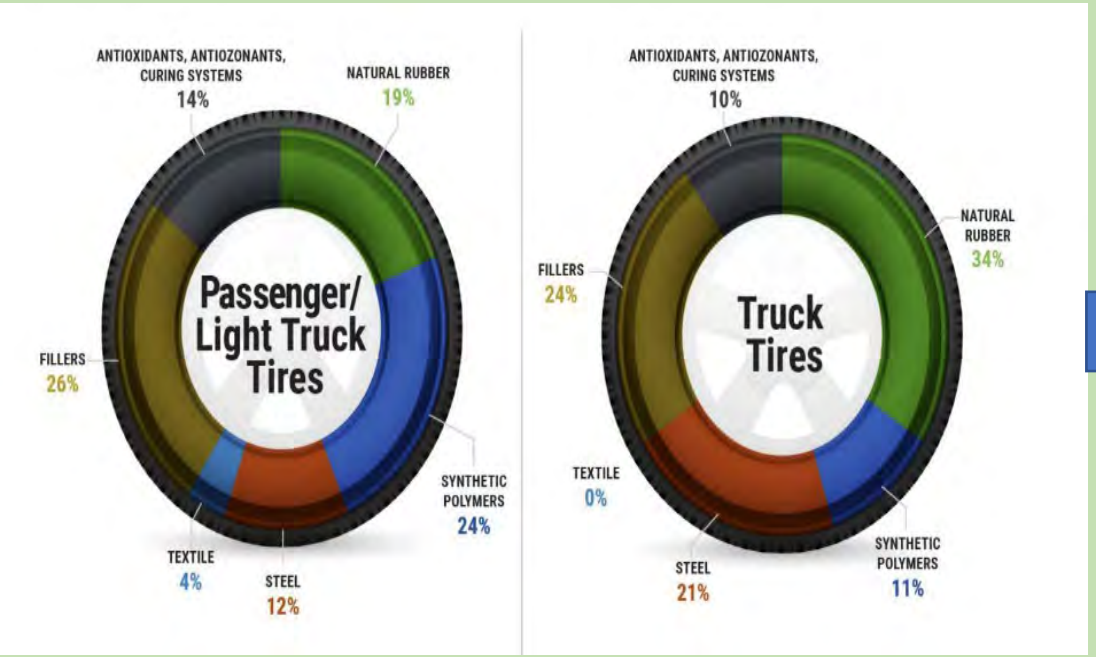
CHANGE IS ON THE WAY: LIKE ALWAYS!

- ROAD CONSTRUCTION INDUSTRY NOT THE FIRST TO SEE SUSTAINABILITY CHALLENGES
  - AUTO MANUFACTURING
  - ELECTRICAL POWER GENERATION
  - IRON AND STEEL CASTINGS
  - AGRICULTURE

- EXPECT SOME/ALL OF FOLLOWING
  - GROWING SUSTAINABILITY PRESSURE
  - EARLY FOCUS ON PLANT OPERATIONS, NOT ROAD DURABILITY
    - EPDs WILL QUANTIFY CONSUMED ENV. SERVICES
    - PRICE ATTACHED TO ENV. SERVICES
  - "LOW BID" WILL INCLUDE COSTS
  - LONG-TERM FOCUS: ROAD DURABILITY
- MARKET/PRACTICES/COMPETITION WILL ADJUST
- SMARTER, FASTER, BETTER WILL THRIVE

LEADERSHIP AND VISION, TECHNOLOGY, STRATEGIC INVESTMENT, CAPITAL ACCESS WILL SEPARATE WINNERS AND LOSERS

ENGINEERED CRUMB RUBBER (ECR): A TOOL IN YOUR CONSTRUCTION/SUSTAINABILITY PLANS



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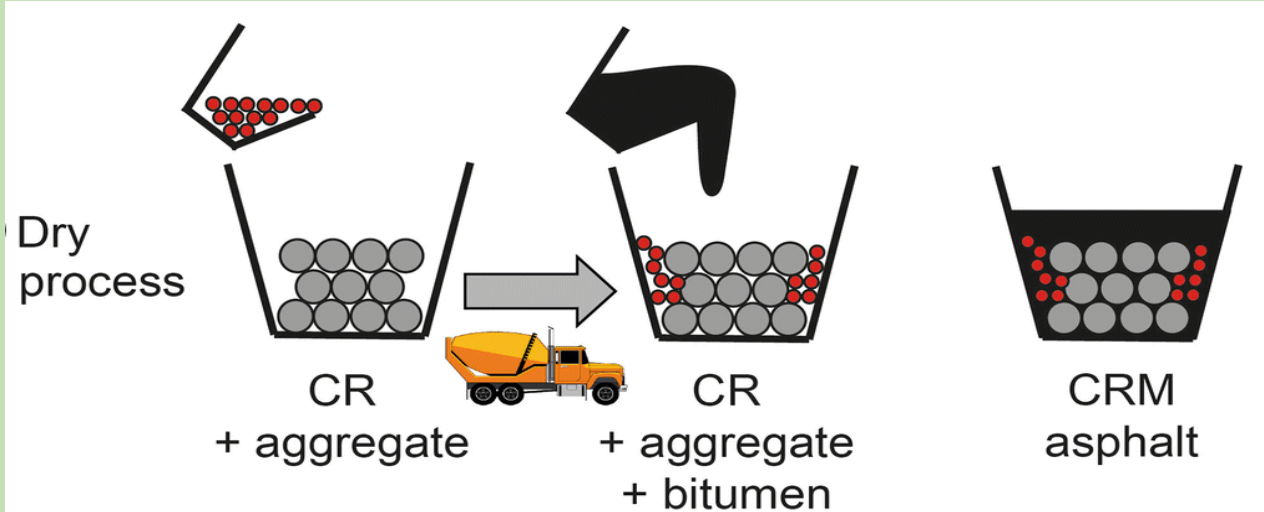
SYNTHETIC AND TIRE RUBBER IN ASPHALT

- RUBBERS USED AS A BINDER MODIFIER:
  - SYNTHETIC RUBBER (POLYMER) MODIFICATION
    - INTEGRATION WITH HEATED BINDER
    - RUTTING/CRACKING RESISTANCE
    - HEAVY TRAFFIC ROADS
  - “WET PROCESS” TIRE RUBBER BINDER MODIFIER
    - SUSPENDED IN HEATED BINDER, (CANNOT MELT, LITTLE DEPOL.
    - ABSORPTION STIFFENS BINDER
    - CRUMBS LIMIT CRACK PROPAGATION
    - HEAVY TRAFFIC ROADS
    - PRIMARY USE IN MANDATE STATES

- RUBBER USED AS A MIX MODIFIER: “MODERN DRY PROCESS”
  - ENGINEERED/MODIFIED SCRAP TIRE CRUMB RUBBER
  - ADDED LIKE FIBER
  - ABSORPTION STIFFENS BINDER
  - CRUMBS LIMIT CRACK PROPAGATION
  - HEAVY, MEDIUM, LIGHT TRAFFIC ROADS



TIRE RUBBER ASPHALT HISTORY

- WET PROCESS RUBBER:
  - MANDATED BY FHWA IN 1991
  - REJECTED BY INDUSTRY
    - ROAD PERFORMANCE SIMILAR TO PMA
    - TOO HARD TO USE
    - SETTLING
    - TOO EXPENSIVE
  - PMA DOMINATES HEAVY TRAFFIC ROADS
- DRY PROCESS RUBBER
  - MODERN DRY PROCESS STARTED IN EARY 2000s
    - ENGINEERED TIRE RUBBER PRODUCT
    - EASY/EASIER TO USE
    - NO SETTLING
    - LESS EXPENSIVE THAN PMA
    - ROAD PERFORMANCE SIMILAR TO PMA
  - WORKS WELL WITH BMD
  - SPECIFICATION STATES INCREASING

WHAT IS DRY PROCESS MIX MODIFICATION?

- OLD WET PROCESS RUBBER MODIFICATION
  - COARSE CRUMB RUBBER ADDED TO HEATED ASPHALT BINDER
  - STIRRED OR MIXED FOR HOURS
  - AGITATED BINDER/RUBBER BLEND SHIPPED TO ASPHALT PRODUCER
  - STORED AND AGITATED IN SPECIAL HEATED TANK
  - VISCOUS RUBBER/BINDER BLEND PUMPED INTO MIX
- MODERN DRY PROCESS MODIFICATION
  - FINE ECR ADDED LIKE FIBERS DURING MIX PRODUCTION
  - DURING MIXING/HOLD/TRANS. RUBBER HEATS, ABSORBS BINDER LIGHT ENDS, RUBBER SWELLS
  - BINDER DYNAMIC VISCOSITY INCREASES
  - ECR INCREASES FRACTURE ENERGY

SIMILAR FIELD RESULTS

MODERN DRY PROCESS MIX MODIFICATION WITH ECR

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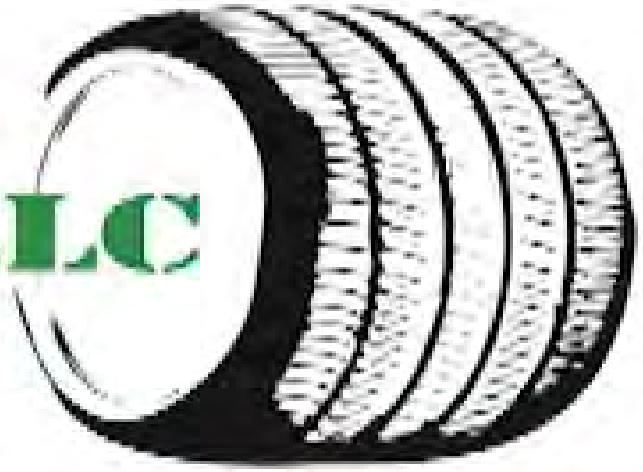

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Engineered Crumb Rubber Technology

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WHAT IS ENGINEERED CRUMB RUBBER?

- FEEDSTOCK: CRUMB RUBBER FROM CAR AND TRUCK TIRES
- ISO-COMPLIANT MFG. PROCESS
- COMPLIES WITH MULTIPLE ASTM AND AASHTO STANDARDS:
  - SIZE
  - CLEANLINESS
  - CHEMISTRY
  - MOISTURE CONTENT
- WHAT MAKES ECR DIFFERENT?
  - CONTROLLED GRAIN SIZE
  - FINE, FLOWABLE POWDER
  - CHEMISTRIES TO REDUCE INTERACTION TIME
  - ELIMINATION OF STICKINESS, WORKABILITY ISSUES

DRY PROCESS ECR IN LAB, MIX DESIGNS

- MIX DESIGN
  - ECR ADDED ON TOP OF MIX (MORE FINES ADDED TO MIX)
  - SMALL AMOUNT OF SUPPLEMENTAL BINDER ADDED TO COAT, FILL ECR
  - 9 MICRON FILM THICKNESS
- LAB PROCEDURES
  - CRUMB RUBBER IS A DYNAMIC ADDITIVE
    - CR ABSORBS BINDER, SWELLS AT RATES CONTROLLED BY TEMPERATURE
    - BINDER ABSORPTION STIFFENS BINDER
    - SWOLLEN CRUMB PINS, DEFLECTS CRACKING
  - RUBBER AND BINDER PRE-MIXED BEFORE ADDITION TO BUCKET MIXER
  - AGGREGATE HEATED BEFORE MIXING WITH RUBBER/BINDER BLEND
  - GYRATORY PILLS SHOULD COOL BEFORE REMOVAL
- IMPACT ON LAB MIX PERFORMANCE
  - 10-12% ECR = TWO-GRADE BUMP
  - 10-12% ECR = MATERIAL IMPROVEMENT IN CRACKING, RUTTING TESTS

MODERN DRY PROCESS IN PRODUCTION

- ON-SITE MODIFICATION OF MIX
- ADJUSTABLE FEED RATE
  - MORE ECR, STIFFER MIX,
  - MORE ECR, LESS CRACKING
  - ON/OFF CONTROL
- ONE BASE BINDER, NO SPECIAL BINDER TANK(S)
- ECR FEED SYSTEMS: BULK OR FIBER FEEDER
- NO SPECIAL LAYDOWN EQUIPMENT
- NO ISSUES WITH FIELD COMPACTION

WHAT HAPPENS TO YOUR MIXES WITH ECR?

DRY PROCESS ECR MIX IMPACTS: RUTTING RESISTANCE

- DURING PRODUCTION
  - ECR ADDITION
  - CONTROLLED PRODUCTION TEMPERATURES
  - LIGHT END ABSORPTION
  - INCREASED BINDER VISCOSITY
  - INCREASED RUTTING RESISTANCE
- ECR ADDS NO AGED BINDER
- APPROXIMATELY 10% ECR BY WEIGHT OF BINDER = TWO GRADE BUMPS

0% ECR **5% ECR** **10% ECR**

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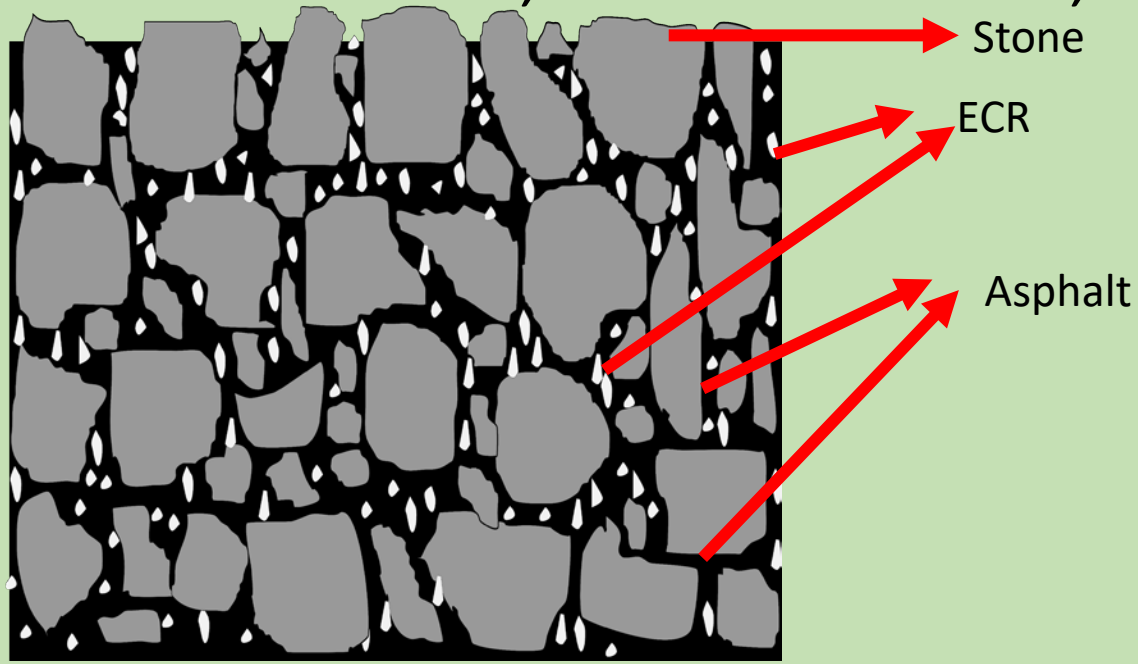
ECR MIX IMPACTS: SLOWER SURFACE OXIDATION

- RUBBER ADDS CARBON BLACK TO MIX
- RUBBER ADDS ANTI-OXIDANT OILS DURING MIX PRODUCTION
- RUBBER PAVEMENTS SLOW AGING, WITH DELAYED OXIDATION SURFACE CRACKING

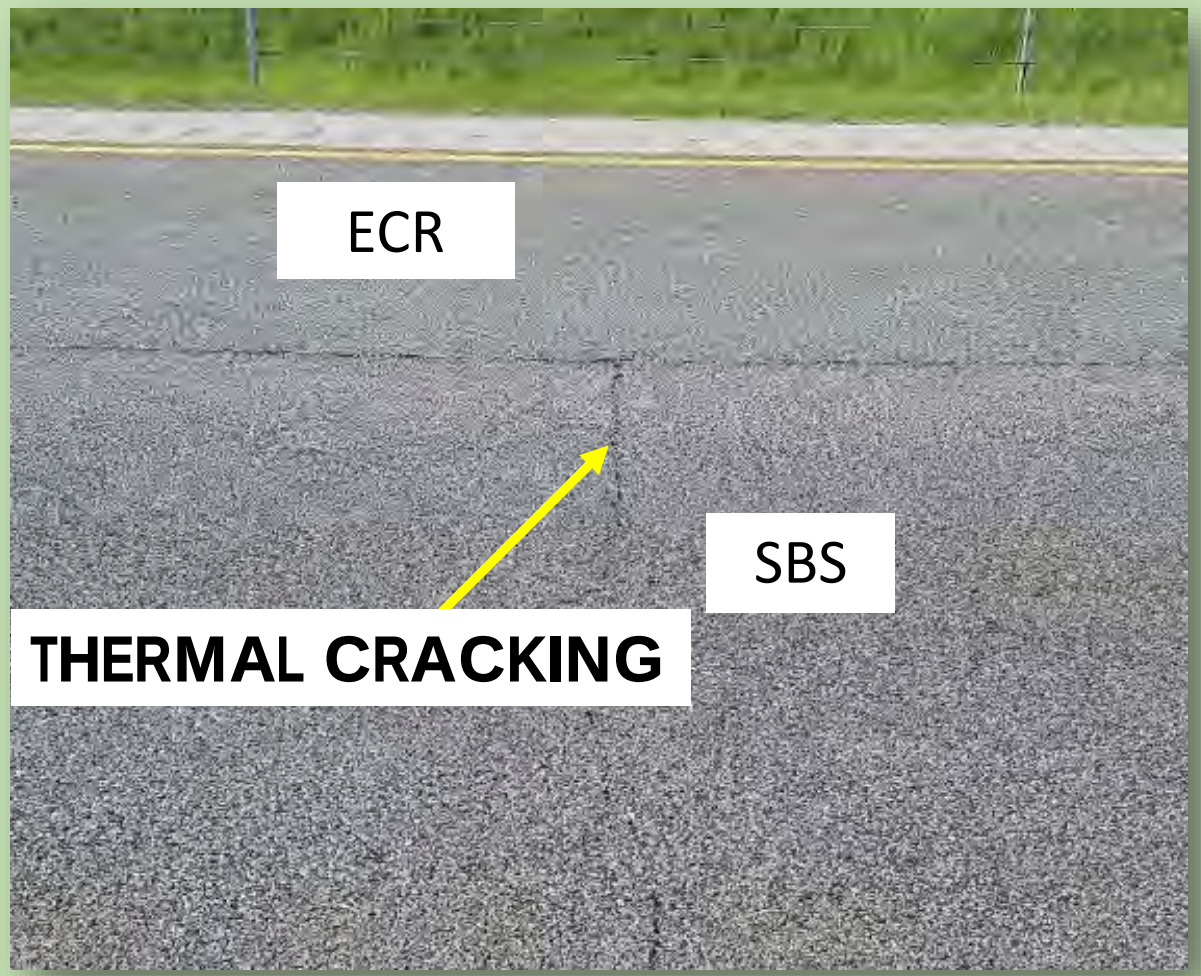
YEAR-OLD TX HOT MIX

15-YEAR-OLD TX ECR MIX

ECR DRY MIX IMPACTS: CRACKING RESISTANCE – THERMAL, REFLECTIVE, FATIGUE



SCHEMATIC OF A PAVEMENT CROSS-SECTION



RATH *ET AL. TRANSP. RES. REC.*, 2020

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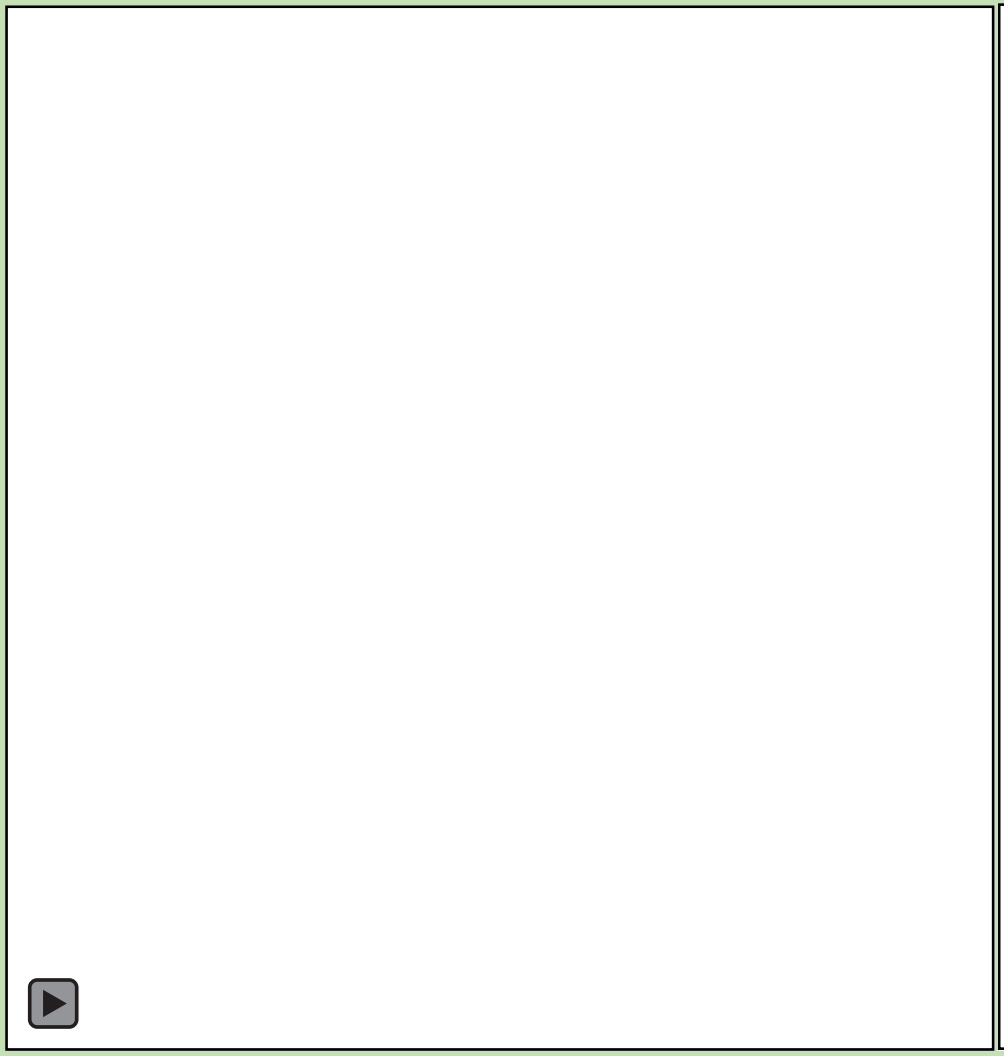
NUMERICAL SIMULATION (FRACTURE PATH)

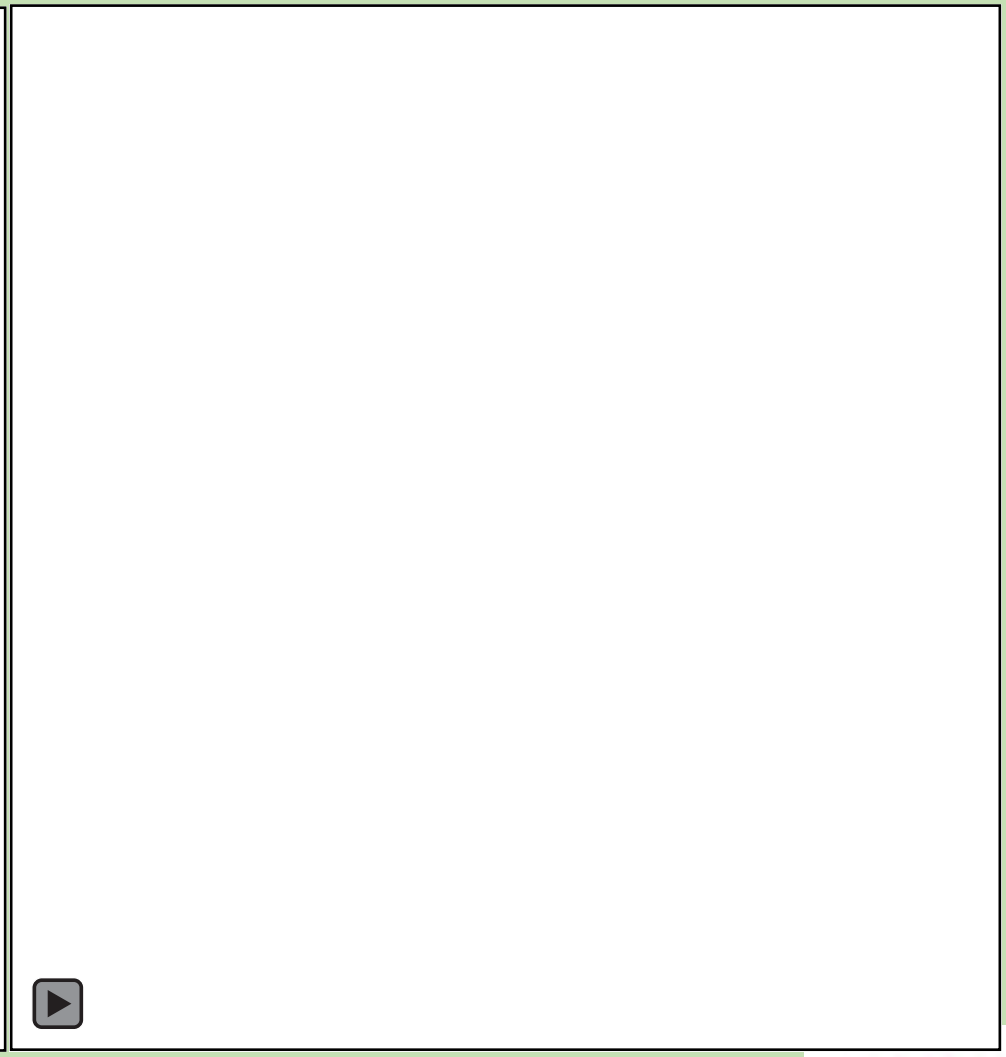
Elements

- Aggregate (9.5-12.5mm)
- Aggregate (4.75-9.5mm)
- Asphalt Mastic
- Rubber Particle

Cracks

- Aggregate-Aggregate
- Aggregate-Mastic
- Aggregate-Rubber
- Mastic-Mastic
- Mastic-Rubber
- Rubber-Rubber





ASPHALT MIXTURE WITHOUT RUBBER

ASPHALT MIXTURE WITH RUBBER

FRACTURE ED 64 -22

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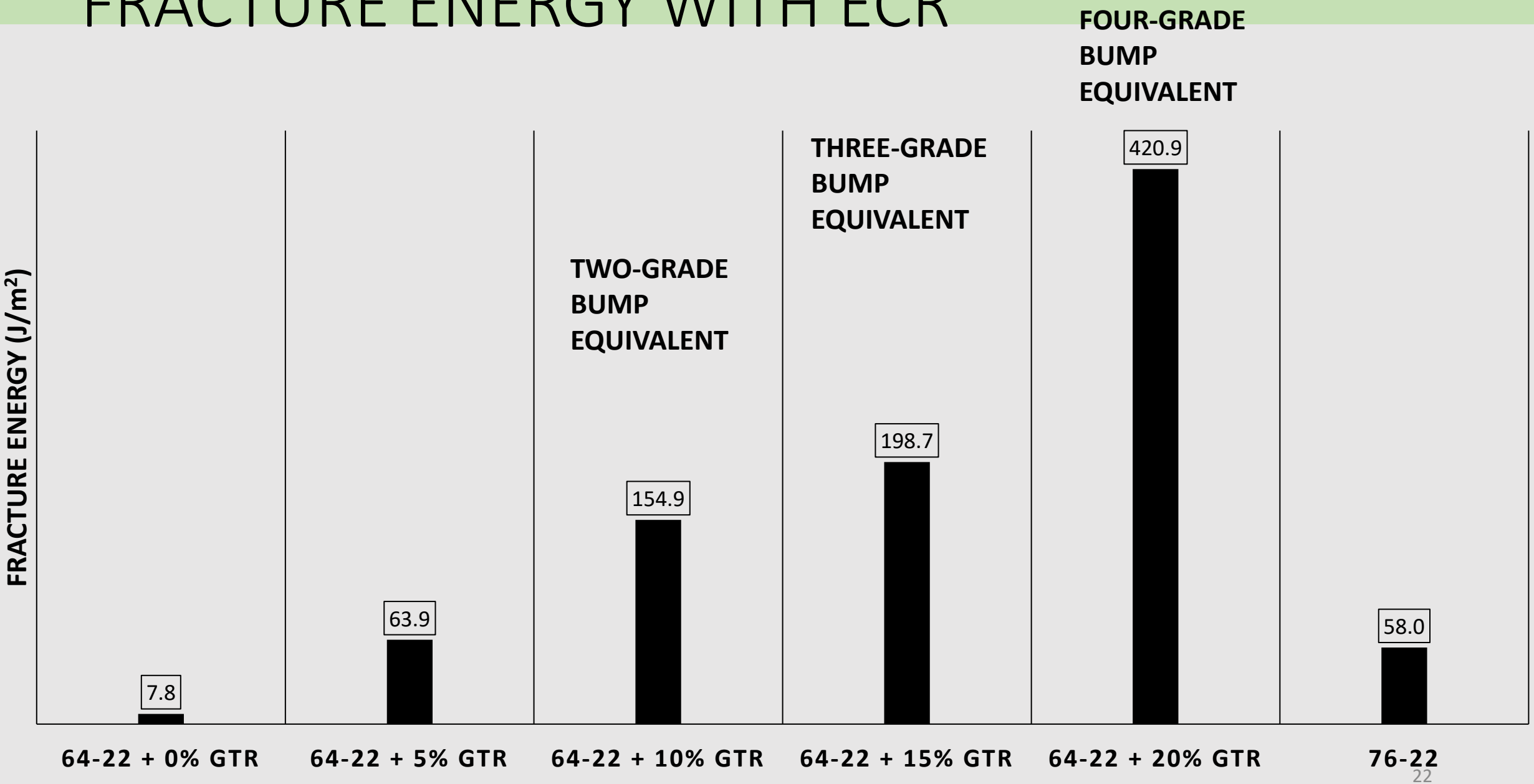
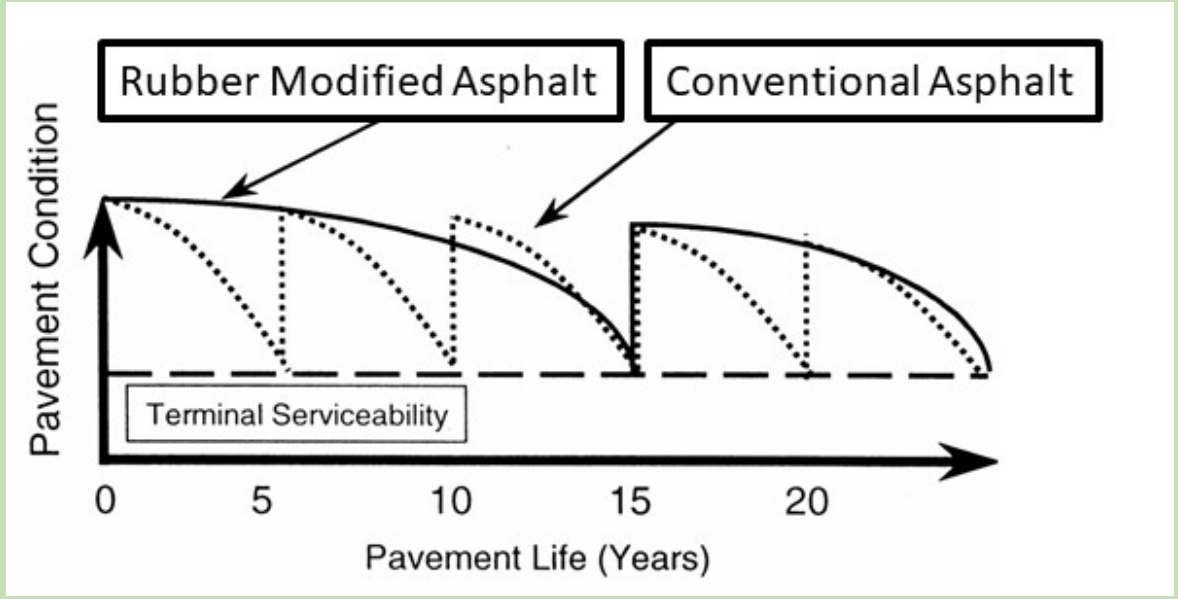
FRACTURE BEHAVIOR: POLYMER-MODIFIED BINDERS

FRACTURE ENERGY WITH ECR



WET/TB/DRY PROCESS RUBBER IMPROVES ROAD PERFORMANCE

- 30 YEARS OF WET, DRY TESTING
- RUBBER ASPHALT ROADS
  - QUIETER
  - MORE DURABLE PAVEMENTS
  - THINNER PAVEMENTS POSSIBLE
  - BETTER TRACTION
  - IMPROVED ROAD LCC
- PERFORMANCE COMPARABLE TO POLYMER MODIFIED PAVEMENTS: 10:3
- EXTENSIVELY USED IN CA, TX, AZ
- GOOD FIELD RESULTS



From: Hicks, Lundy, and Epps, 1999

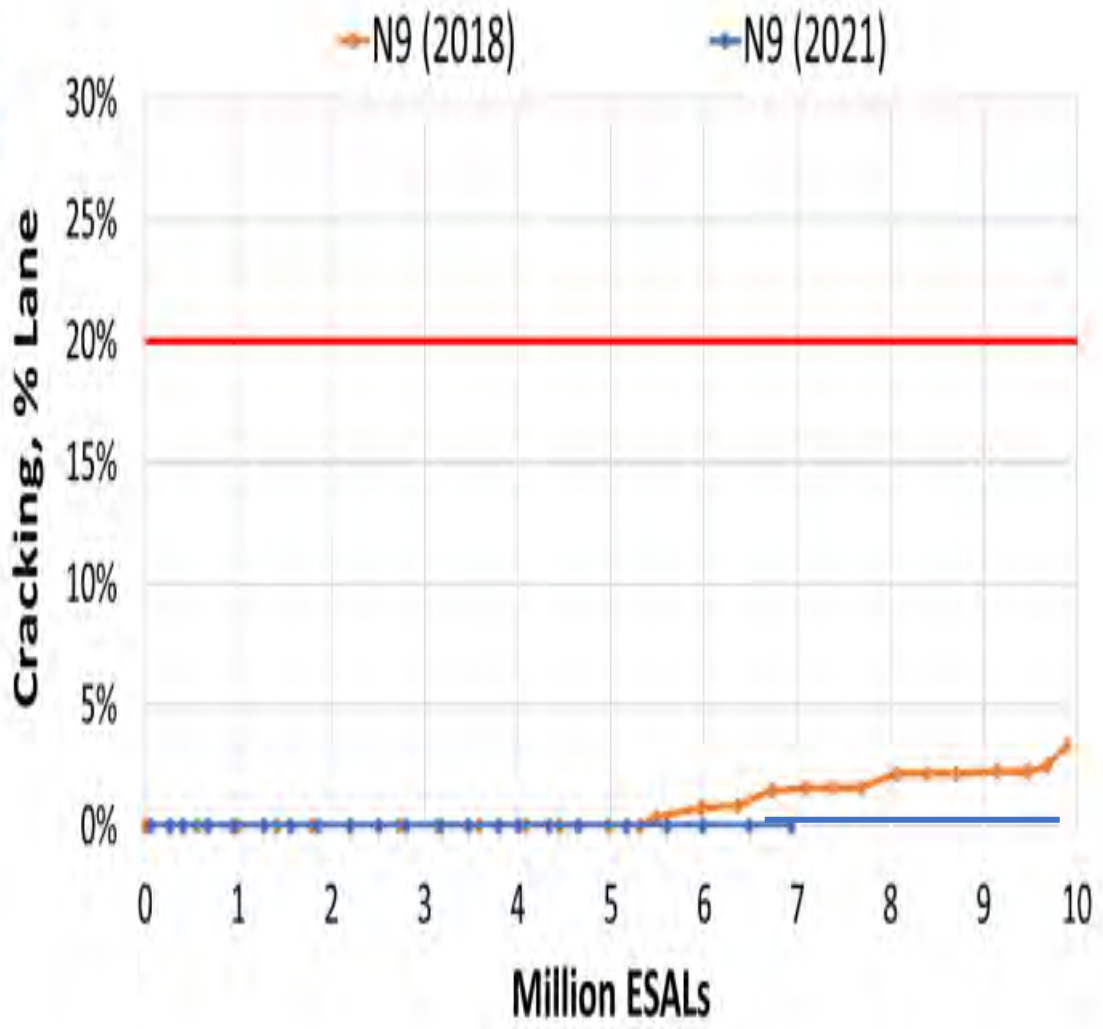
HOW DOES DRY PROCESS ECR PERFORM IN THE FIELD?

NCAT TEST TRACK SECTION N-9 2021-2024

- 2018-2021: S-5 DG MIX, 1.5” INLAY
  - PG 76 -28, 15% HIGH-AGED FRAP
  - LOW RUT
  - 4.5 MM HAMBURG, NO IDEAL CT
  - 1.5 MM RUT
  - CRACKING STARTED AT 5 MM ESALs
- 2021-2024: S-5 DG MIX, 1.5” INLAY
  - PG 58 -28, 12% ECR, 15% HIGH-AGED FRAP
  - 9.5 MM HAMBURG, 120 IDEAL CT
  - 2.5 MM RUT, 0% CRACKING
- ECR EXTENDED FOR ANOTHER 10 MILLION ESALs

N-9 CRACKING COMPARISON: 2018, 2021

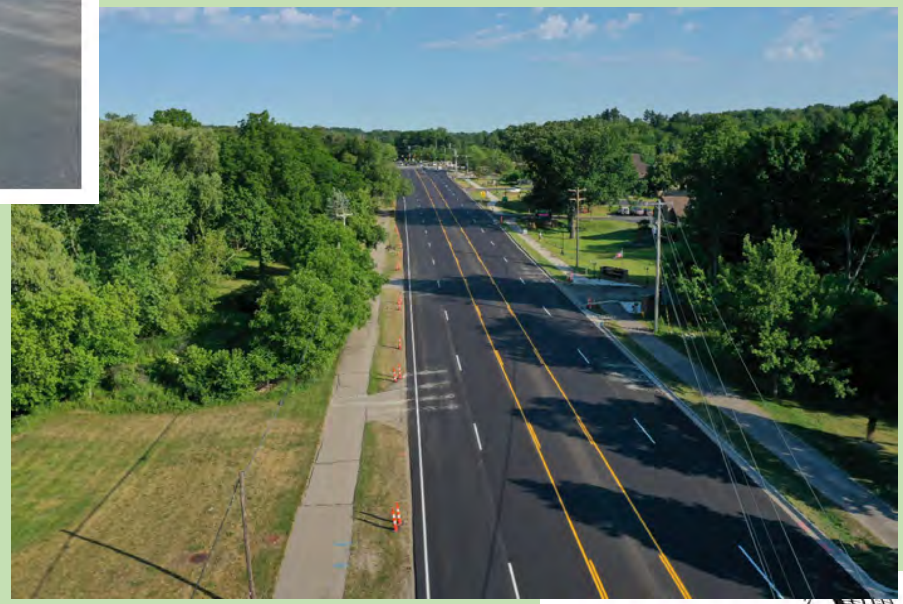
- No cracking



National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

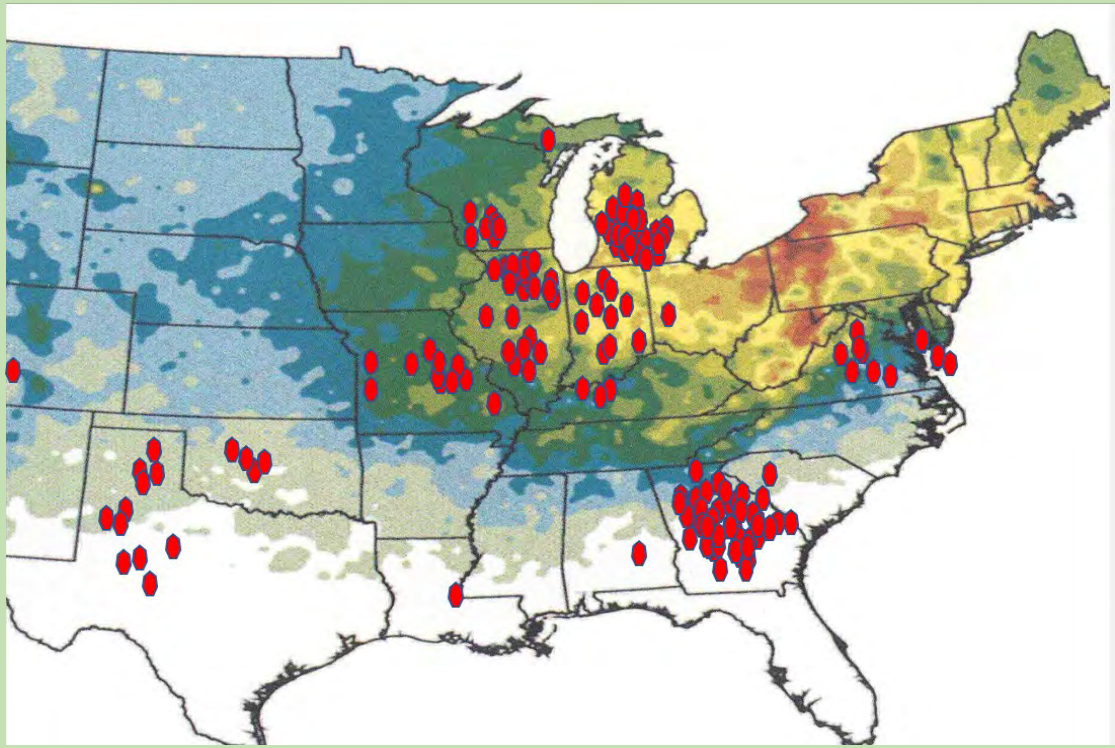
MnROAD
SAFER, SMARTER, SUSTAINABLE PAVEMENTS
THROUGH INNOVATIVE RESEARCH

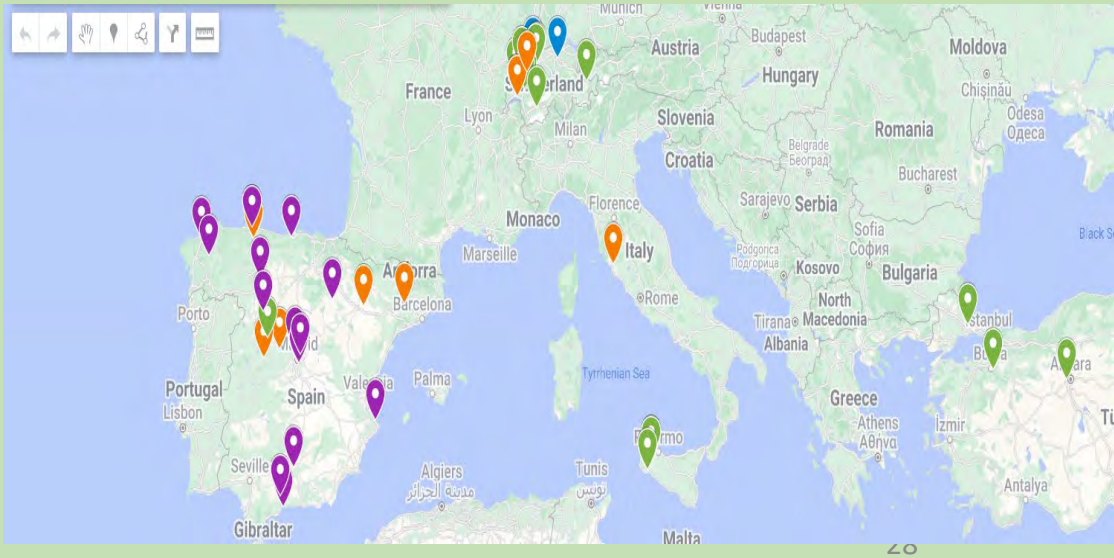
ECR IN THE FIELD: FOCUS ON THERMAL, FATIGUE CRACKING, RUTTING, RECYCLABLES, THICKNESS REDUCTION



ECR: FIELD EXPERIENCE

- APPROACHING 10 MILLION TONS IN SERVICE
- 21 YEARS OF FIELD EXPERIENCE
- 15 US STATES
- >2500 MILES OF INTERSTATES
- >8,000 MILES OF STATE HIGHWAY
- WIDE ARRAY OF MIX DESIGNS
- WIDE ARRAY OF CLIMATES





FIELD PERFORMANCE EXPERIENCE: HEAVY TRAFFIC HIGHWAYS AND ARTERIALS

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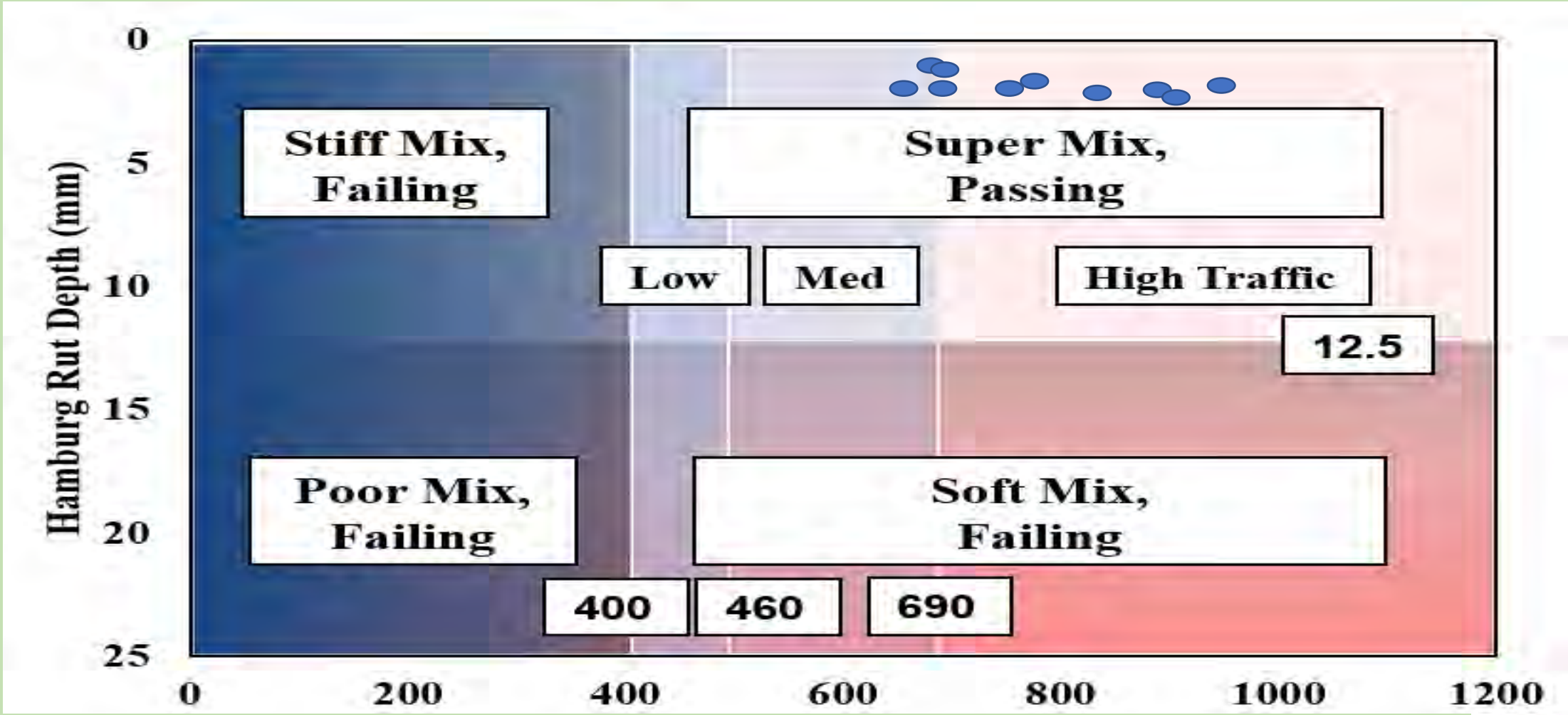
GEORGIA 2006 I-75 OVERLAY: PMA VS. ECR

- HEAVY TRUCK TRAFFIC
- 1.25’ PEM OVERLAY
- PMA CONTROL
- 30% RAP CONTENT
- HIGH PAVEMENT DURABILITY
  - EXPECTED LIFE: 5 YRS.
  - ACTUAL LIFE: 14 YRS.
  - SAME AS PMA PAVEMENT
- $3/TON SAVINGS

ILLINOIS 2016 I-88, I-294 BMD: SMA HIGH-RECYCLE ECR MIX

- HEAVY TRAFFIC, E PAVEMENT, SEVERE COLD
- BALANCED MIX DESIGN
  - 46 -34 BINDER
  - 40% RAP
  - 3% RAS
  - 51% ABR
  - 10% ECR
  - SIX GRADE BUMP
- POLYMER CONTROL
- COMPARABLE BMD TESTING
- ECR MIX BETTER THERMAL CRACKING RESISTANCE
- STARTING 9TH YEAR OF SERVICE
- HUNDREDS OF PAVEMENT MILES

BALANCED MIX PERFORMANCE PLOT: IL DRY PROCESS SMA RUBBER PROJECTS



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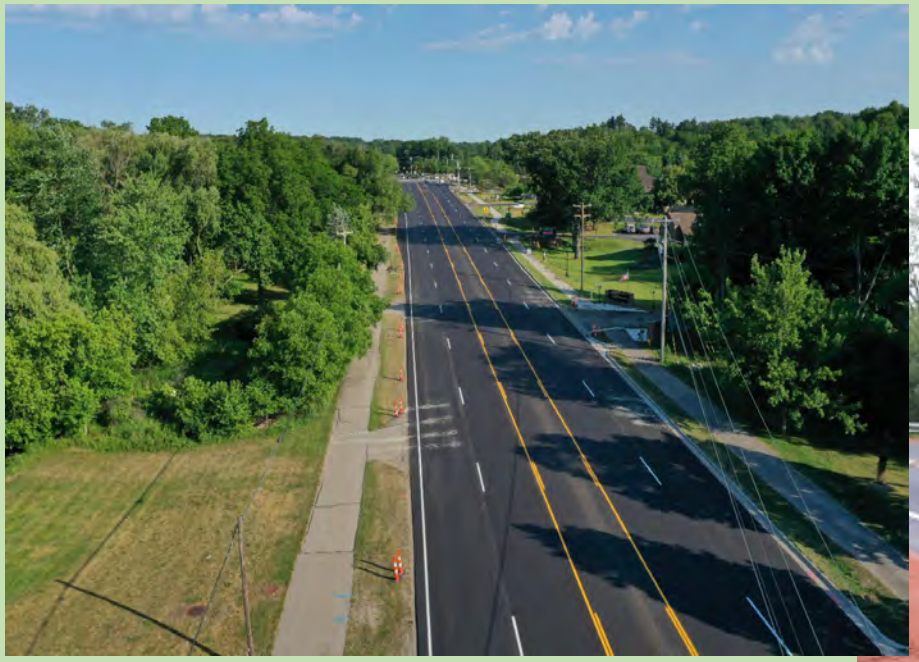
MEDIUM, LIGHT-DUTY PAVEMENTS



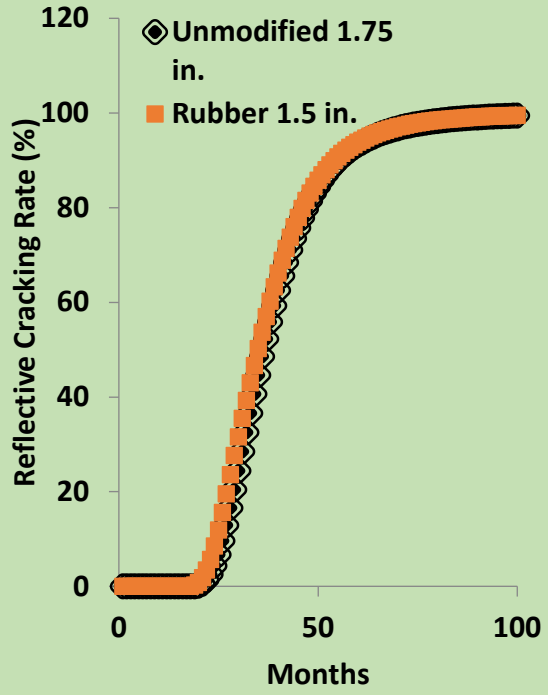
ECR ENHANCES THIN OVERLAY STRUCTURAL STABILITY, DURABILITY

- COMPARE 1” DG OVERLAY WITH, W/O ECR
- CONCRETE BASE
- ECR MIX RUTTED 65% LESS THAN STANDARD HOT MIX

CONTROL 4.7 MM RUT DEPTH

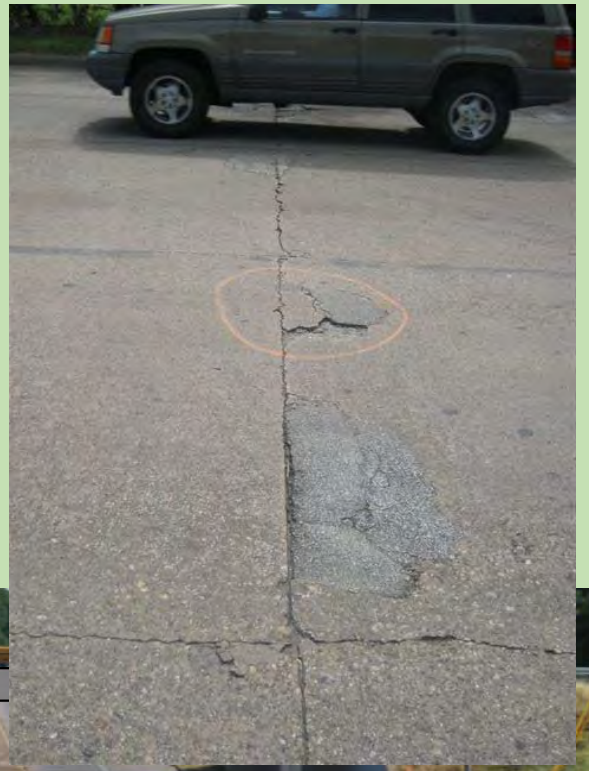
ECR 1.7 MM RUT DEPTH

- CRACKING SIMULATIONS SHOW THINNER ECR PAVEMENTS STILL DURABLE



TX 2008 PUMFRIES ROAD 1” THIN OVERLAY DENSE GRADED MIX

- MEDIUM DUTY ROAD
- ASPHALT OVERLAID ON CRACKED, SPALLING CONCRETE
- FATIGUE CRACKING, RUTTING ENVIRONMENT
- NO MATERAL RUTTING, RUBBER RESISTS EXPANSION OF JOINT CRACKS
- **2.5-3 X LIFE** COMPARED TO STANDARD 2’ HOT MIX OVERLAY



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COMMERCIAL APPLICATIONS: 4 YEAR-OLD ASCE HQ SUSTAINABLE PARKING LOT

BMD BEHAVIOR OF ECR MIXES

DENSE-GRADE PRODUCED MIX

- HLWT
  - RUTTING IN THE 3-8 MM RANGE AFTER 20,000 PASSES
- IDEAL CT
  - SCORING IN THE 100-300 RANGE
- DCT
  - SCORING IN THE 400-800 RANGE

SMA PRODUCED MIX

- HLWT
  - RUTTING IN THE 3-6 MM RANGE AFTER 20,000 PASSES
- IDEAL CT
  - SCORING IN THE 140-400 RANGE
- DCT
  - SCORING IN THE 600-1300 RANGE

INTERPRET WITH CARE

ECR VALUE PROPOSITION

MODIFIED ASPHALT HEAVY TRAFFIC ROADS

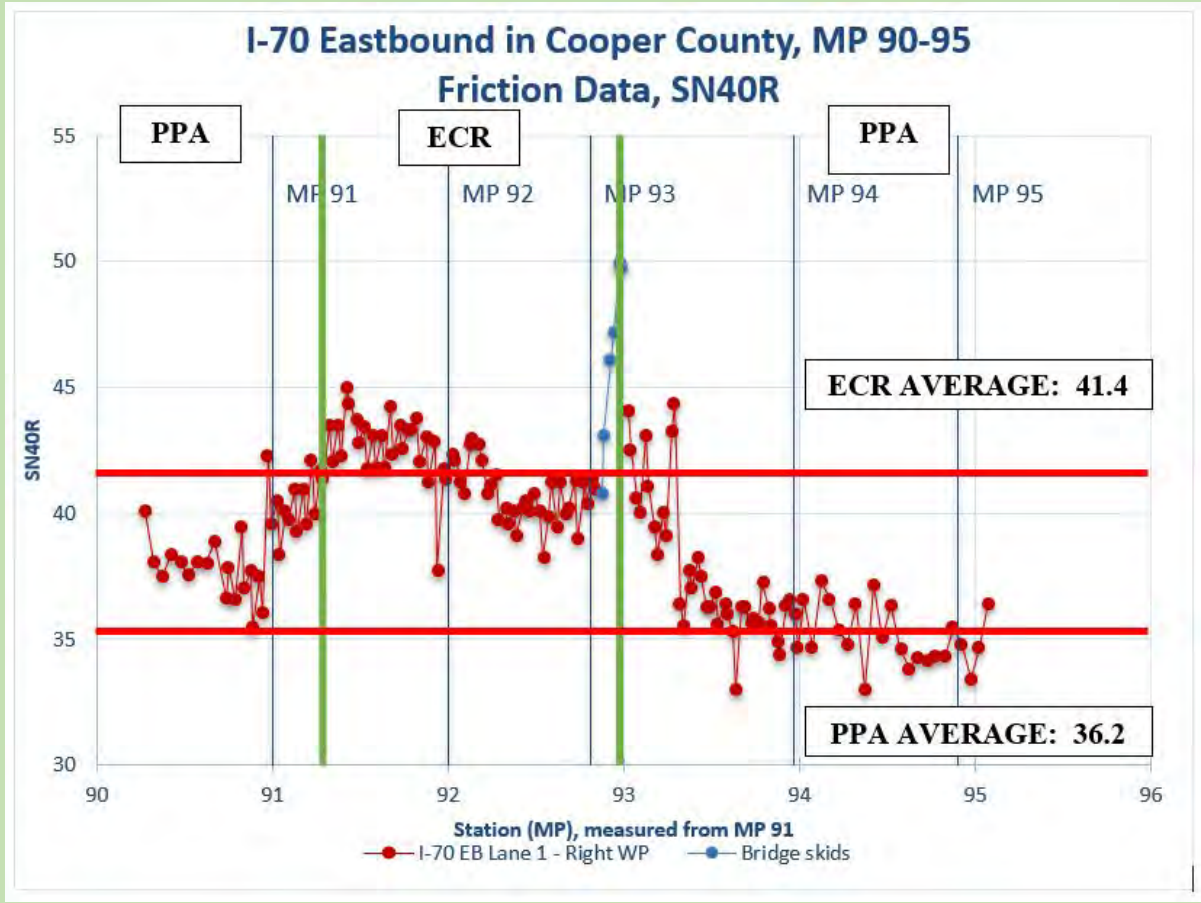
- $2-$5 LESS THAN POLYMERS
- PPA/FIBER SMA MIXES: $1.50/MIX TON SAVINGS
- BMD AND ECR = INCREASED RECYCLABLES OPPORTUNITY
- COMPARABLE PAVEMENT LIFE
- 10-15% INCREASE IN WET WEATHER TRACTION
- 4-10 DB REDUCTION IN ROAD NOISE
- LOWER CARBON FOOTPRINT

STANDARD HOT MIX LIGHT AND MEDIUM TRAFFIC ROADS

- PAVEMENT LIFE EXTENSION
- THINNER OVERLAYS
  - $10-$20/TON SAVINGS
- BMD AND ECR = INCREASED RECYCLABLES OPPORTUNITY
- 10-15% INCREASE IN WET WEATHER TRACTION
- 4-10 DB REDUCTION IN ROAD NOISE
- LOWER CARBON FOOTPRINT

LONG-TERM ECR BENEFITS – FUNCTIONAL

- ECR RESULTS IN SMOOTHER PAVEMENT SURFACES OVER LIFESPAN, **INCREASING DRIVER COMFORT** AND **REDUCING VEHICLE REPAIR COSTS**
- THE SMOOTHER, STIFFER, AND MORE ELASTIC SURFACE OF ECR **CONSERVES FUEL**
- TRAVEL OVER GAP-GRADED ECR LEADS TO 1.4 TO 2.0 TIMES **REDUCED TIRE TREAD WEAR AND TIRE PARTICLE EMISSIONS** AS COMPARED TO DRIVING ON CONCRETE (ALLEN ET AL., 2006)
- ECR ALSO RESULTS IN **HIGHER SKID RESISTANCE** COMPARED TO UNMODIFIED AND POLYMER-MODIFIED MIXTURES (MEASURED RECENTLY IN COOPER COUNTY, MO)



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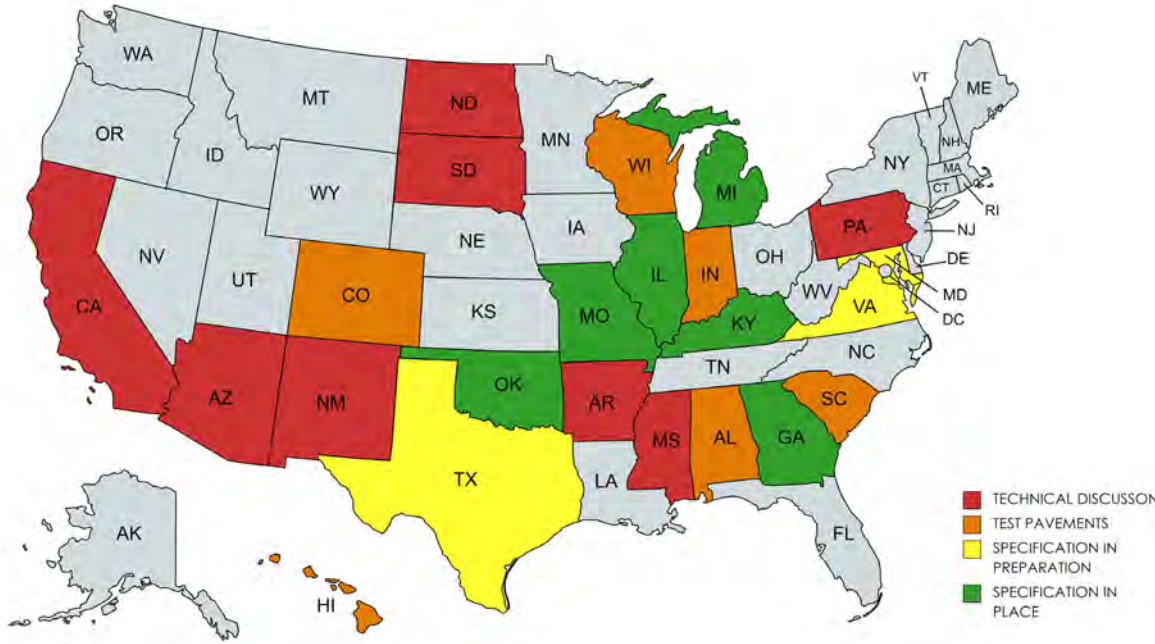
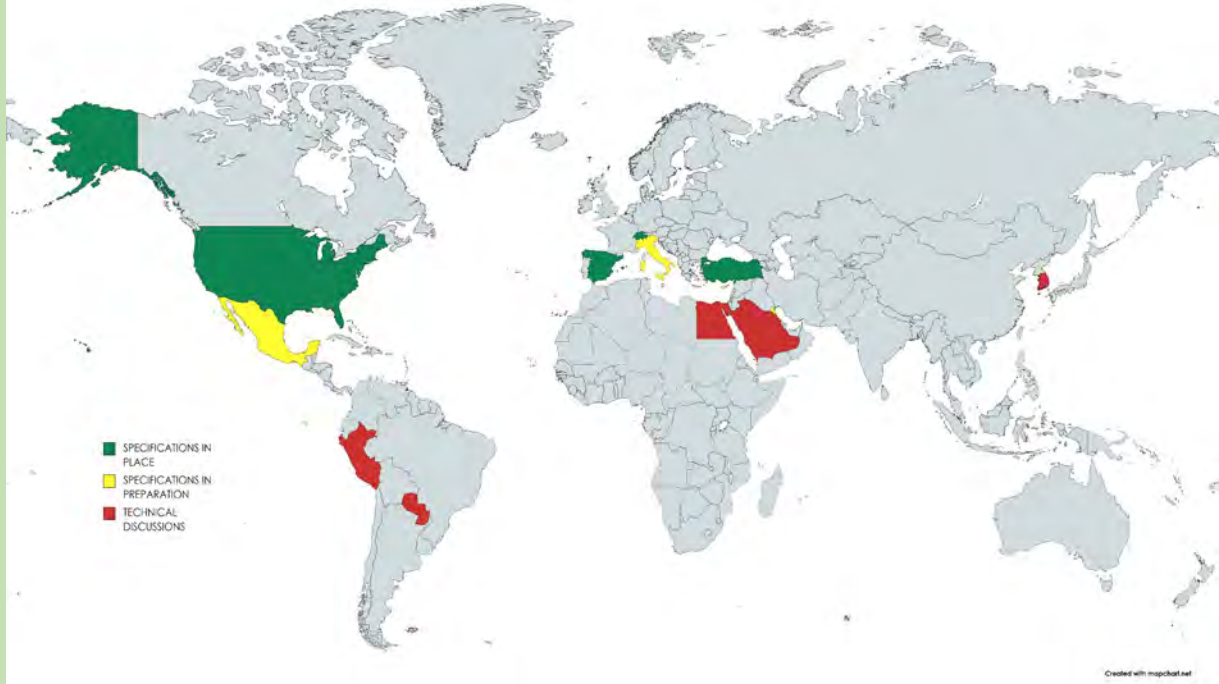
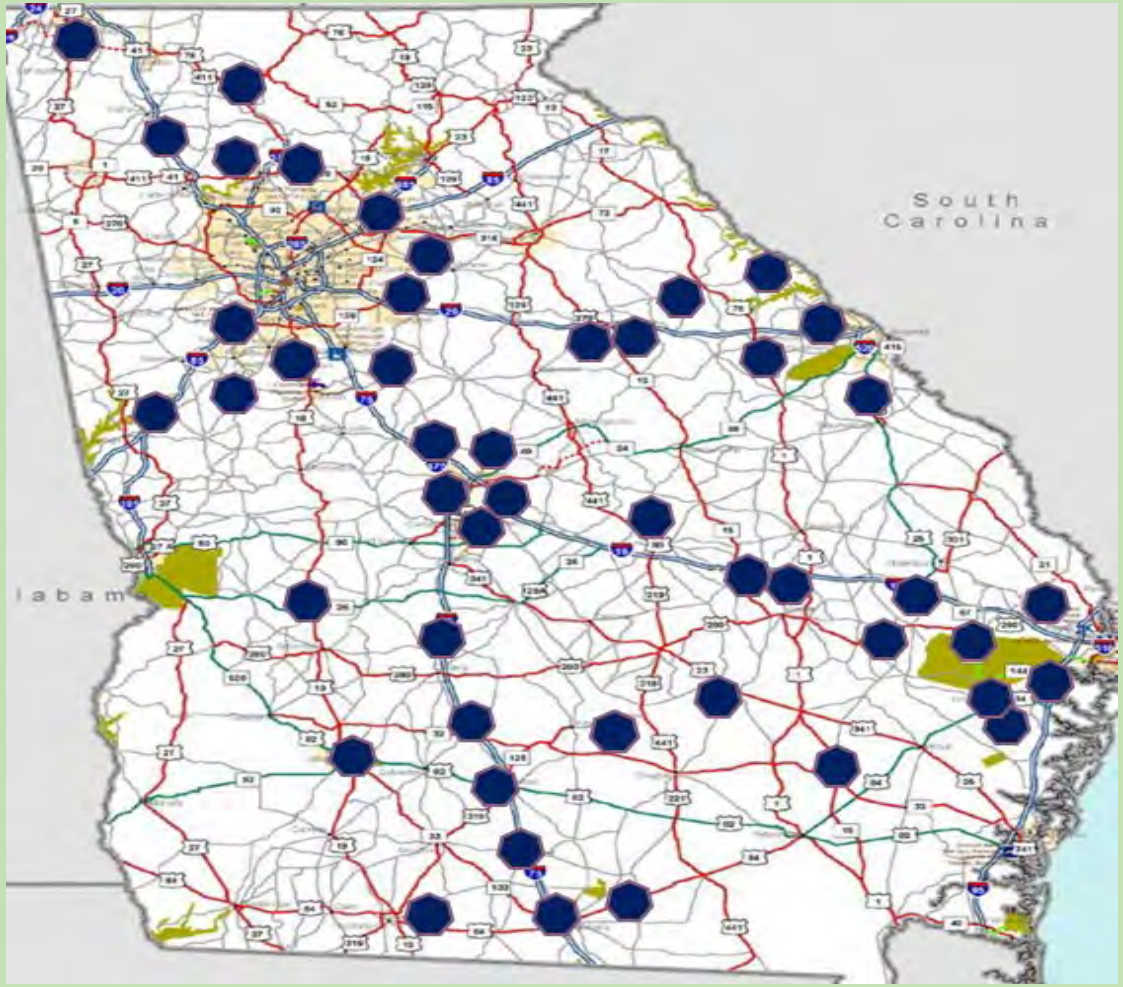
EVIDENCE OF MARKET ACCEPTANCE

- EXPANDING BMD TRANSITION
- GROWING SPECIFICATIONS, PLACED TONNAGE
  - NEW STATES AND COUNTRIES
  - SUB-STATE SPECS (CITY/COUNTY)
- EXPANDING PLANT CUSTOMER BASE: >150 PLANTS
- PENETRATION OF MODIFIED ASPHALT MARKET: OLDER STATES
- INCREASING SALES, REPEAT CUSTOMERS





PENETRATION OF TB, PMA MARKETS: GA AND IL TOLLWAY



Year	Route	GTR Type	GTR Quantity (Mix Tons)	
2008	I-90	Terminal Blend	92,200	
	I-355	Terminal Blend	23,000	
2009	I-90	Terminal Blend	92,200	
	I-355	Terminal Blend	26,700	
2010	I-355	Terminal Blend	76,300	
2015	I-88	Terminal Blend	16,000	
	I-88	Dry Plant Added	1,000	Trial
2016	I-88	Dry Plant Added & Terminal Blend	2,700	Trial
2018	I-88	Terminal Blend	66,500	
	I-88	Dry Plant Added	66,500	
	I-355	Dry Plant Added	98,000	
	I-294	Dry Plant Added	17,000	
2019	I-94	Dry Plant Added	66,000	
	I-94 Spur	Dry Plant Added	15,000	
	I-294	Dry Plant Added	41,000	
	I-90	Dry Plant Added	1,500	
	Rt 47/I-88	Dry Plant Added	4,000	

2014-2021: 70% OF PMA MARKET OUTSIDE ATLANTA

IL TOLLWAY TRANSITION TO ECR FROM TB/POLY

ECR EFFECTS ON PAVEMENT LCA

- IL TOLLWAY HIGH-RECYCLE SMA MIX DESIGN
- AVERAGE US MIX GHGs: 60 KG
- ESTIMATED EPD EFFECTS OF HIGH RECYCLE MIX

  ABR = 51% = 18 KG CO2e/TON

  AVOIDED POLYMER ADD: 2 KG CO2e/TON

  HIGHER PLANT HEAT: -1 KG CO2e/TON

  COMPARABLE PAVEMENT LIFE SPANS

  NET GHG BENEFIT: 19 KG CO2e/TON

ANCILLARY EPD BENEFITS

Impact category	Impact of Rubberized road with respect to Conventional road
Climate change (kg CO_2 eq)	-34%
Ozone depletion (kg CFC-11 eq)	-38%
Human toxicity (kg 1,4-DB eq)	-27%
Photochemical oxidant form. (kg NMVOC eq)	-34%
Terrestrial acidification (kg SO_2 eq)	-35%
Freshwater eutrophication (kg P eq)	-20%
Terrestrial ecotoxicity (kg 1,4-DB eq)	-37%
Freshwater ecotoxicity (kg 1,4-DB eq)	-26%
Water depletion (m^3)	-30%
Fossil depletion (kg oil eq)	-37%

SUSTAINABILITY AND ASPHALT PAVEMENTS

- NAPA PUSHING ROAD TO NET ZERO, EPDS
- HOW WILL NET ZERO/EPDs/LCAs IMPACT ROAD CONSTRUCTION?
  - PLANT ADJUSTMENTS TO LOWER ENERGY USE
  - AGENCY METRICS CHANGE (HOW DOES SUSTAINABILITY MESH WITH LOW BID?)
  - MORE DURABLE PAVEMENTS (MOST IMPORTANT)
- SUSTAINABLE "REAL ESTATE" OPTIONS
  - BEST: REDUCES COSTS
  - ACCEPTABLE: BREAKS EVEN
  - WORST: COSTS MONEY
- BEST PAVING DURABILITY OPTIONS COULD INCLUDE:
  - INTELLIGENT COMPACTION
  - MIX/AGGREGATE SELECTION
  - RECYCLABLES CONTENT
  - BINDER CONTENT
  - WARM MIX
  - WIDE ARRAY OF ENGINEERED ADDITIVES

FUTURE FOCUS: ECR

- TIRE RUBBER IS A GLUTTED WASTE STREAM
- MORE TIRES THAN DEMAND
  - 200 MILLION TIRES/YR IN US (400 MILLION TONS OF ASPHALT)
  - 1.6 BILLION TIRES/YR GLOBALLY
- LESS EXPENSIVE THAN OTHER MODIFICATION OPTIONS
- PRODUCES A MORE SUSTAINABLE/DURABLE ROAD
- STRATEGIC VALUE FOR THIS INDUSTRY

THANK YOU

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Elastiko®
Engineered Crumb Rubber Technology

BMD Performance Testing

Balanced Mix Design Performance Testing for Job Mix Approval NJSP-21-08A

1.0 Description. This work shall consist of providing asphalt mixture in accordance with Sec 403 that meet the minimum Balanced Mix Design (BMD) performance requirements of cracking and rutting resistance. The BMD performance requirements will be applied to SuperPave mainline wearing surface mixtures only. Bituminous binder and base, level course, shoulder, and pavement repair mixtures are excluded from the BMD requirements.

2.0 Performance Testing. Acceptable test results meeting the performance requirements for both Cracking Tolerance Index (CT_{Index}) and Hamburg Wheel Track (HWT) shall be submitted with the mix design for approval. No incentive/disincentive payment will be imposed during production. The performance requirements for each mix type are detailed in the table below:

Performance Criteria / Mix Type	Cracking Tolerance Index (CT_{Index})	Hamburg Wheel Track (HWT)
Non SMA Mixtures	45 minimum	12.5 mm maximum rut depth @ designated wheel passes in Section 8
SMA Mixtures	135 minimum	12.5 mm maximum rut depth @ designated wheel passes in Section 8

New Mix Design

DG Mix Design

Air Void = 3.0%

VMA = 15.3%

VEA = 12.3%

Results for 9,000 tons

Averages

Air Voids = 2.81%

VMA = 14.82%

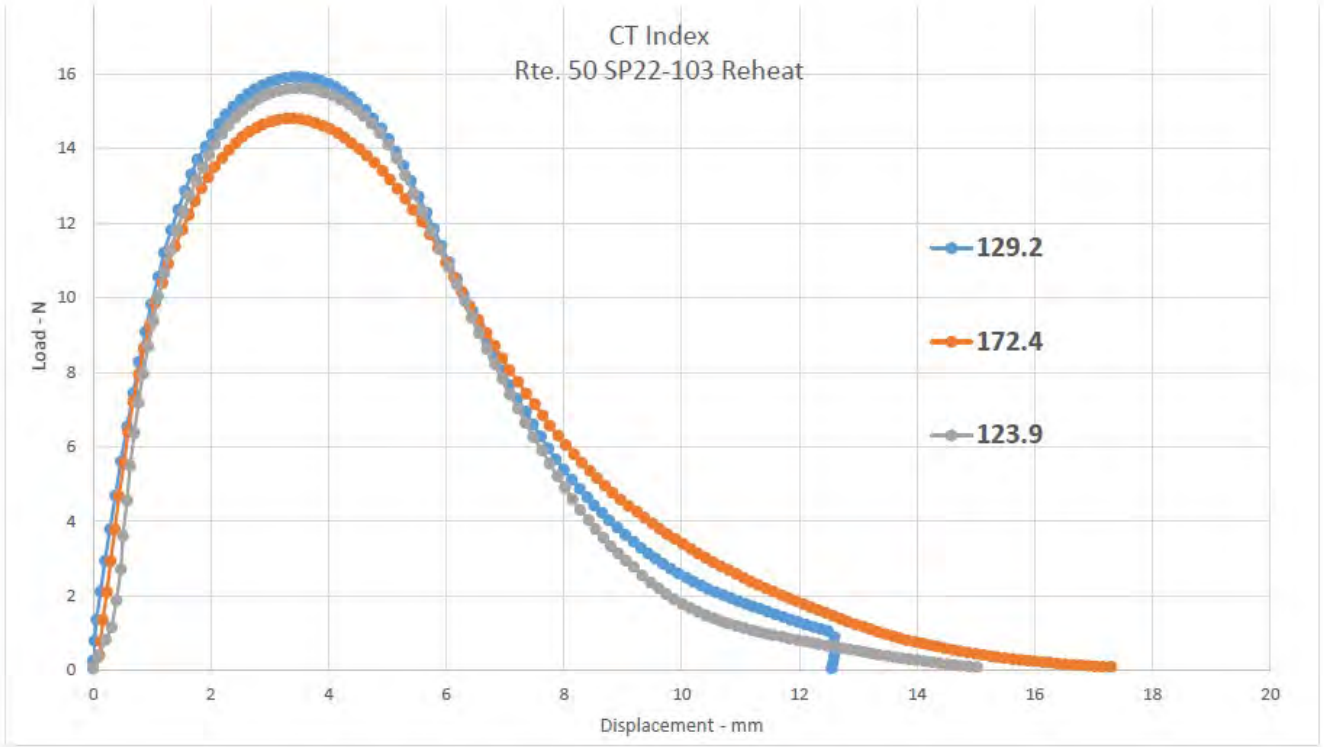
AC = 5.81%

Density = 94.82%

Low = 93.6%

High = 96.6%

CT INDEX = 142



Average CT Index **142**

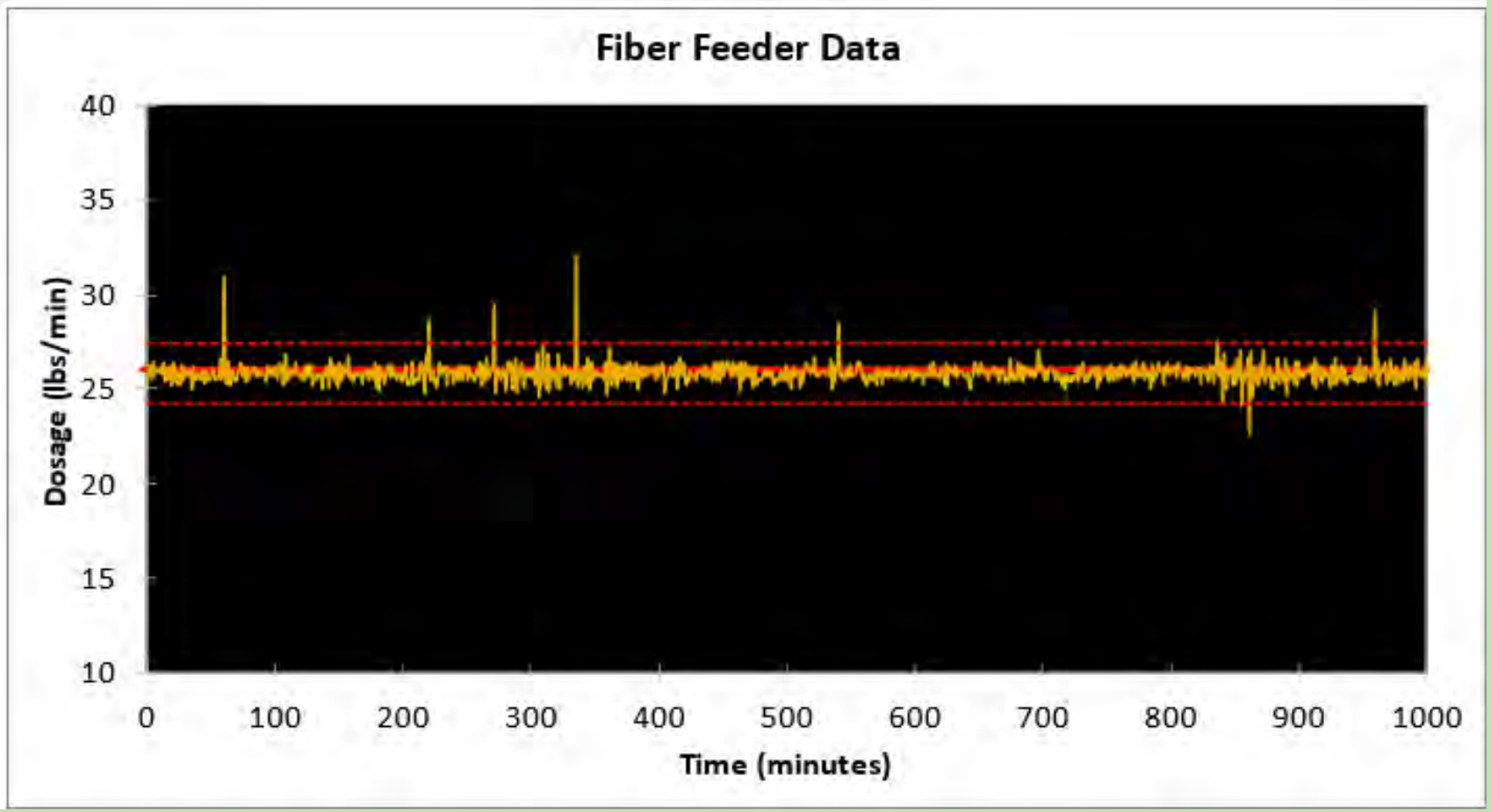
West Contracting Performance Testing

2020 Projects

Mix Type	Date Sampled	12.5mm SMA Tonnage	135 CT Index	12.5 max Rutting	% Binder
PG 64-22V	14-Aug	3221.1	213	4.6	6.2%
PG 64-22 + GTR	20-Aug	0-5000	220	6.2	5.8%
PG 64-22 + GTR	31-Aug	5000-10000	392	5.1	6.4%
PG 64-22 + GTR	3-Sep	10000 -15000	742	8.3	6.2%
PG 64-22 + GTR	21-Sep	15000 -20000	587	7.6	6.4%
PG 64-22 + GTR	23-Sep	20000 -25000	590	8.9	6.3%
PG 64-22 + GTR	25-Sep	25000 -30000	599	7.7	6.3%
PG 64-22 + GTR	1-Oct	30000 - 35000	741	9.3	6.3%
PG 64-22V	21-Oct	5000	168	5.3	6.0%
PG 64-22V	23-Oct	5000	212	6.0	6.4%

		19.0mm Dense			
	Date Sampled	Tonnage	35 CT Index	12.5 max Rutting	
PG 64-22 + GTR	9-Sep	N/A	367	11.6	4.9%
PG 64-22 + GTR	10-Sep	N/A	321	8.1	5.2%
PG 64-22 + GTR	28-Sep	N/A	179	7.3	5.0%
		12.5mm Dense			
PG 64-22V + FIBER	24-Oct	3000	119	4.1	5.2%
PG 64-22V + FIBER	31-Oct	9000	135	5.1	5.1%

ACCURACY EVALUATION OF FIBER MACHINE ECR FEED



- 2500 TON RUN
- 1,000 MIN. TOTAL RUN TIME
- MEASUREMENT RATE: 1/MIN.
- PRODUCTION JMF FEED TARGET: 26 LBS./MIN.
- ACTUAL OUTPUT: 25.87 LBS./MIN.
- JMF SHIFT VARIATION: 0.5%