

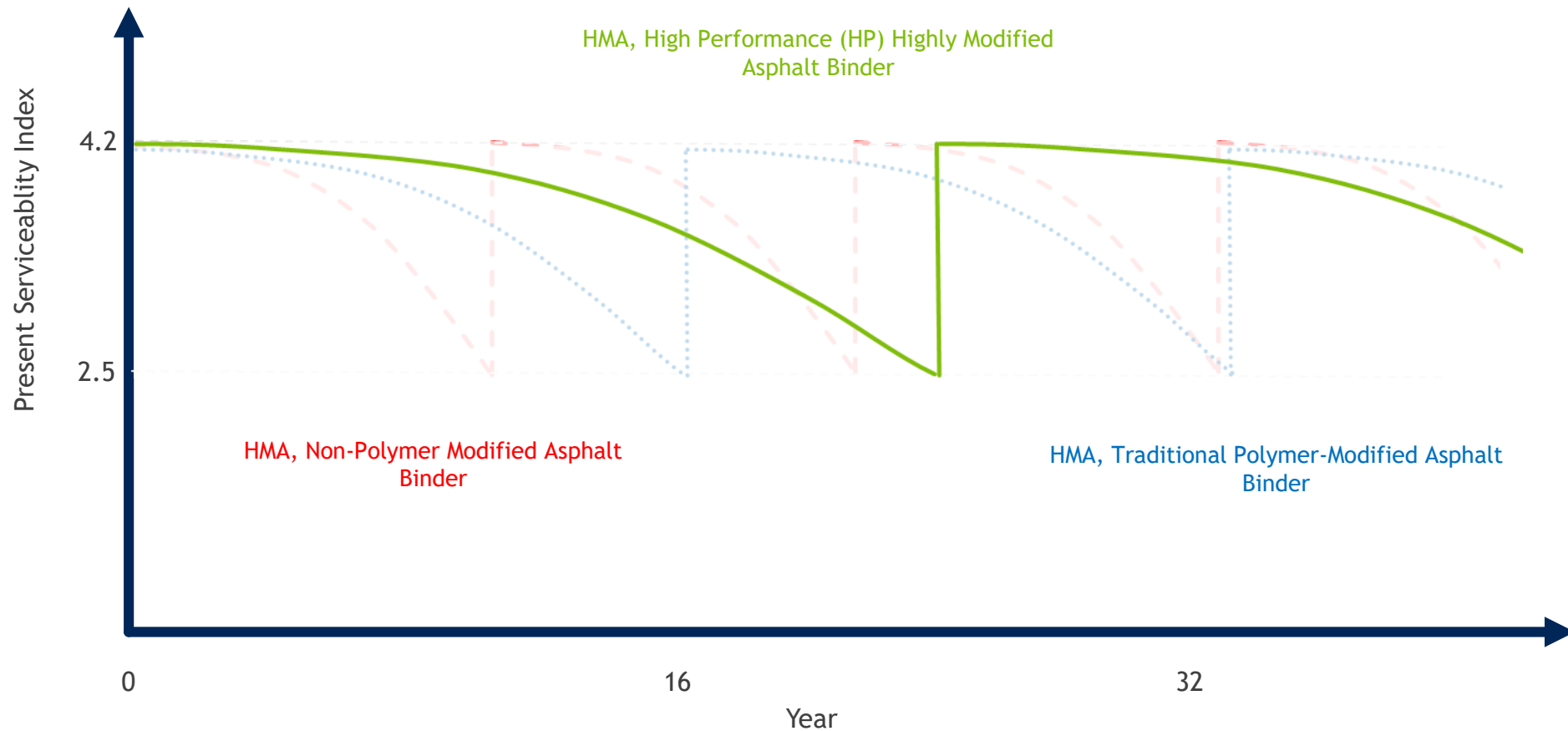


High Performance, Highly Modified Asphalt: The Next Generation of Hot Mix Binders

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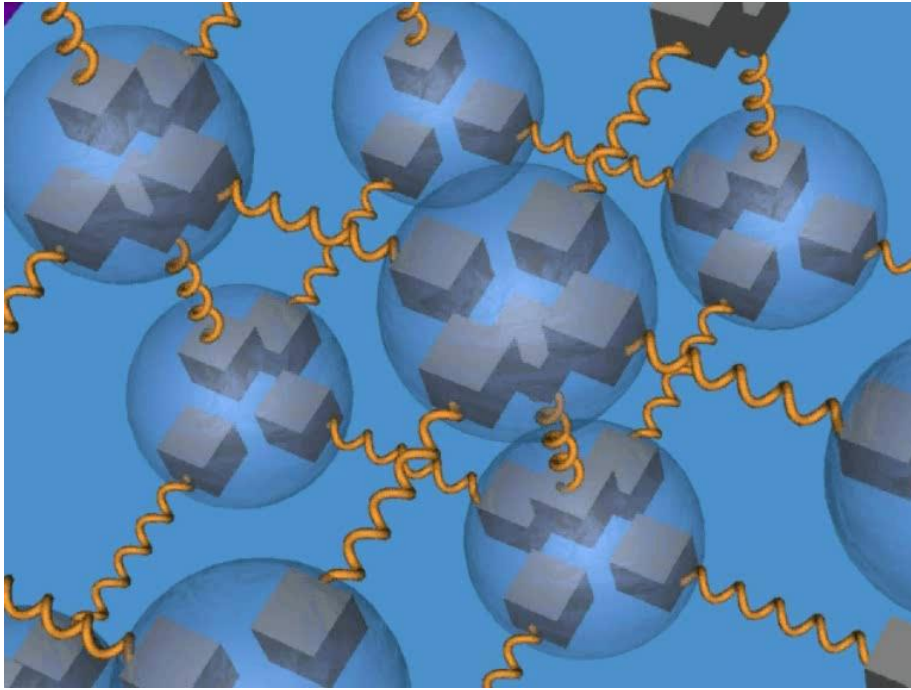
Comparative Performance Concept



What Is High Performance/Highly Modified Asphalt?

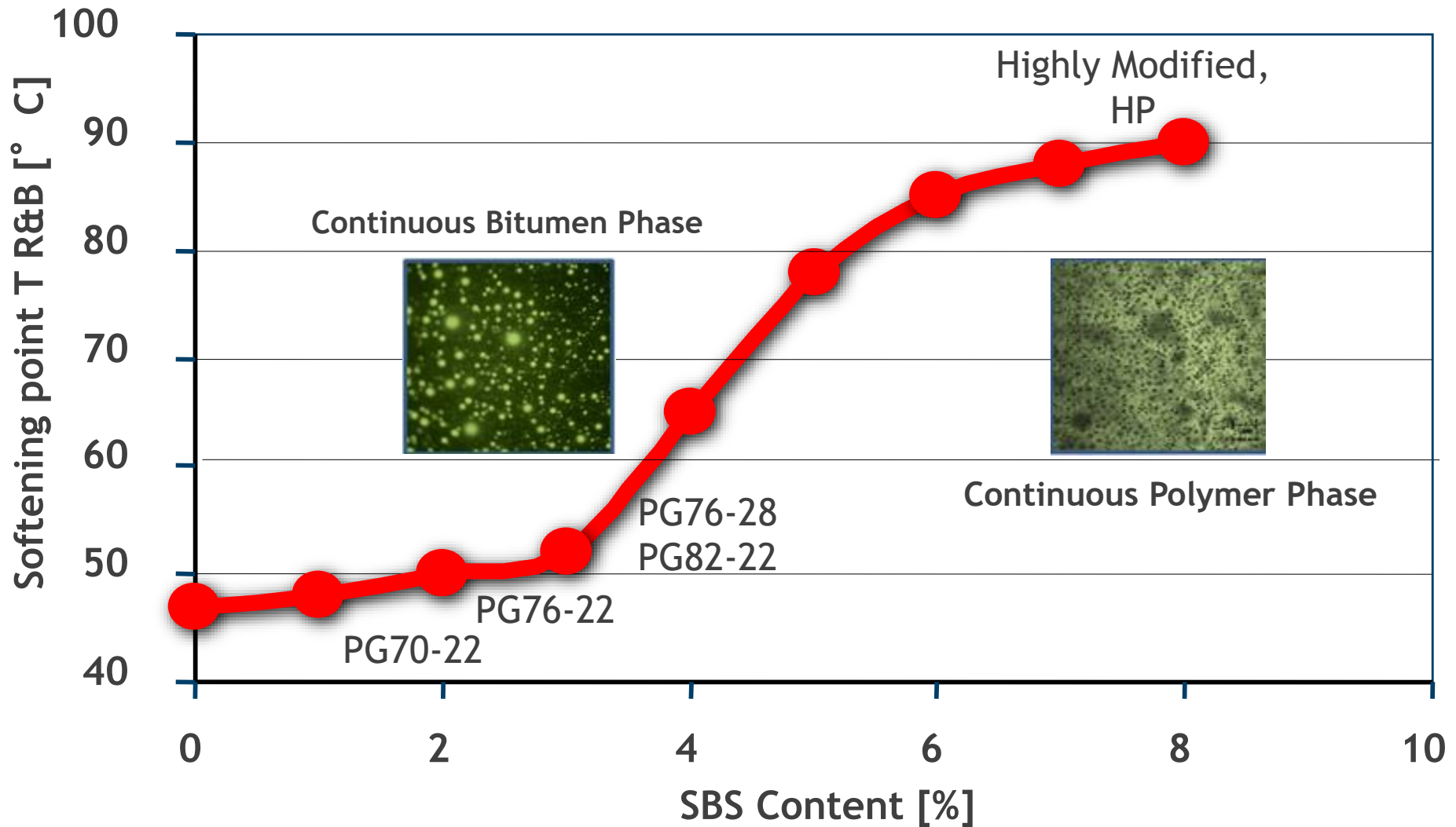
- Highly Modified Asphalt (often called HiMA™ or HPG) is exactly what it says, an asphalt binder with 2-3 X the amount of SBS polymer used to produce grades such as PG76-22
- The resulting binder contains a dense polymer network that significantly improves mixture performance
 - Much less sensitive to temperature changes over the range of service temperatures
 - Much greater resistance to rutting and fatigue cracking
 - SBS polymers are available that allow the use of high polymer content ($\geq 7.5\%$) binders that can be handled at similar temperatures as PG76-22
- In reality, it is an asphalt-extended polymer binder, rather than a polymer-modified asphalt binder

SBS in Asphalt Binder (Bitumen)



- SBS polymer absorbs some of the lighter (maltene) fractions of the bitumen
- Expands and forms an elastomeric network in the bitumen that:
 - Provides an elastic response to loading at high service temperatures where unmodified asphalt binders behave as a viscous fluid
 - Improves adhesive and tensile strength
 - Reduces temperature susceptibility
- Strength of the network depends on the polymer content

“S-Curve” - Effect of increasing SBS content



High Performance-Graded Binder-Proposed Specification

Key features:

- Based on AASHTO M332, instead of M320
 - Using M320 approach, HPG would grade at PG88-28 or PG94-28
- Uses MSCR, tests RTFO-aged binder at 76 °C
 - $J_{nr3.2} < 0.10 \text{ kPa}^{-1}$
 - $R_{3.2} > 90\%$ PAV DSR
 - $(G^*\sin\delta)$ maximum is 4,000 MPa, which is *lower* than either AASHTO specification

High Performance-Graded (HPG) Binder	
Property and Test Method	HPG
Original Binder	
Flash Point, T 48, Min. °C	230
Viscosity, T316, Max. 5.0 Pa-s, test temperature, °C ¹	135
Separation, ASTM D7173, Dynamic Shear, T315, % $G^*/\sin\delta$ Difference ² , Max. 10%, temperature, °C	76
Polymer Content, Tex-533-C ² , Min. %	7.5
Rolling Thin-Film Oven (Tex-541-C)	
Mass change, Tex-541-C, Max. %	1.0
Multiple Stress Creep Recovery, T350, Jnr, 3.2kPa, Max. 0.10 kPa-1, test temperature, °C	76
Multiple Stress Creep Recovery, T350, % recovery, 3.2kPa, Min. 90.0%, test temperature, °C	76
Pressure Aging Vessel (PAV) Residue (R 28)	
PAV aging temperature, °C	100
Dynamic shear, T315 $G^*\sin\delta$, Max. 3,000kPa Test temperature @ 10 rad/sec., °C	25
Creep Stiffness, T313 @ 60 sec ³ S, Max. 300mPa, m-value, Min. 0.30, Test temperature, °C	-18

1. This requirement may be waived at the Department's discretion if the supplier warrants that the asphalt binder can be adequately pumped, mixed, and compacted at temperatures that meet all applicable safety, environmental, and constructability requirements. Use Spindle 21 when testing for rotational viscosity.
2. Determined as the absolute value of the percent difference in $G^*/\sin\delta$ measured on samples taken from the top and bottom: $100 \times (G^*/\sin\delta \text{ (top)} - G^*/\sin\delta \text{ (bottom)}) / G^*/\sin\delta \text{ (top)}$
3. In Tex-533-C, the SBS peak is changed to 699cm⁻¹, representing the polystyrene band.
4. Silicone beam molds, as described in AASHTO T313, are acceptable for use.

NCAT Test Track

[About NCAT](#)[Test Track](#)[Pavement Preservation](#)[Education & Training](#)[Our Research](#)

NCAT's Test Track—the only high-speed, full-scale accelerated pavement testing facility in the world—is a 1.7-mile oval with experimental sections sponsored by highway agencies and the transportation industry.

Want to get involved? Contact us for information on how to become a sponsor.

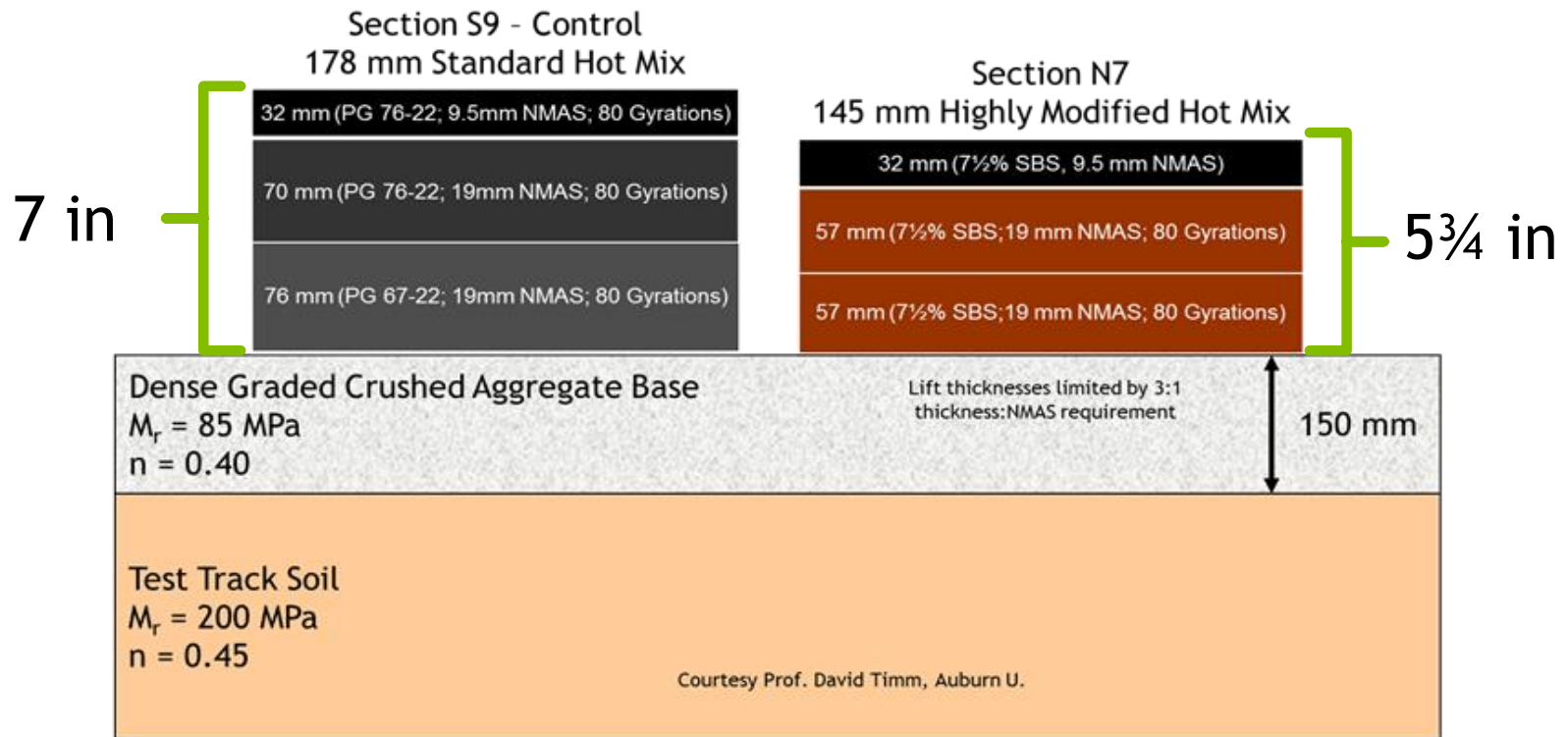
[GET IN TOUCH](#)

About the Test Track

The NCAT Test Track is a national research proving ground for asphalt pavements. Highway agencies and industry sponsors fund research on the 1.7-mile oval in 200-foot test sections. This real-world laboratory allows for cutting-edge experimentation while avoiding the risk of failure on actual roadways. In a step to play a larger role in pavement research, NCAT has also partnered with the Minnesota Department of Transportation's MnROAD facility to focus on two important national issues that impact each agency: pavement preservation and validation of cracking tests.

<http://eng.auburn.edu/research/centers/ncat/testtrack/index.html>

Control (S9) and HiMA™(N7) Section Designs, 2009 Construction (NCAT Report 12-08)



- From the report: “workability and compactability were similar to those of a PG 76-22 binder both in the laboratory and in the field”
- Laboratory mix characteristics, field performance were very different

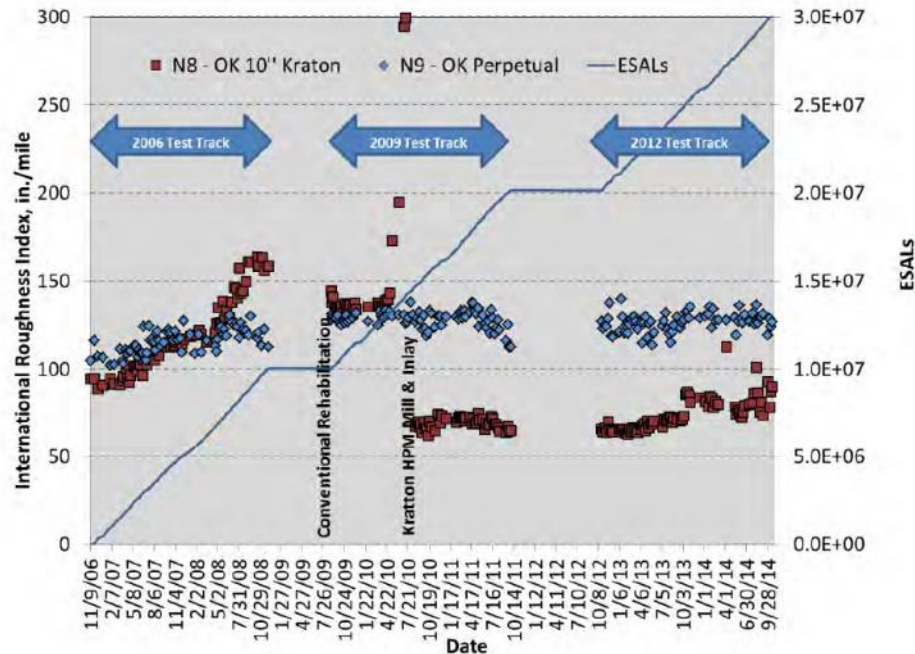
NCAT Results

- Laboratory:
 - Minimal rutting, no moisture damage in Hamburg Wheel Tracking test
 - Fatigue endurance limit 3X higher
 - Less temperature susceptible
- Field
 - After 20 million flexible ESAL, about 4 mm rutting with minor superficial cracking
 - Control had bottom-up fatigue cracking
 - No change in ride quality

Additional HiMA™ work at NCAT

- Section N8 (Oklahoma) rehabilitation
- “Green Group” High Modulus Asphalt (EME) study.
 - HiMA mixture, w/35% RAP provided best mechanical properties, performance
- “Cracking Group” - evaluating different laboratory cracking tests vs field performance
 - Promoting top-down cracking, while avoiding traditional, bottom-up fatigue
 - Thin base/binder lifts (4.25 in) for all 6 test sections
 - No bottom-up cracking after 20 million ESAL
 - Section S6 included HiMA wearing course-minimal superficial cracking observed
- Deep (7.5 in), single lift construction
 - 12.5 mm NMS dense-graded mixture, consistent densities achieved
 - No distress, no change in profile after 10 million ESAL

HiMA™ Rehabilitation, Section N8-Performance



Section N8, Before 2nd Rehabilitation

Figure 4 IRI Evaluation of Oklahoma Perpetual Pavement Sections

- Roughness, rutting stabilized after HPG rehabilitation
- No cracks observed until more than 15 million ESAL
- A resilient alternative for heavy traffic

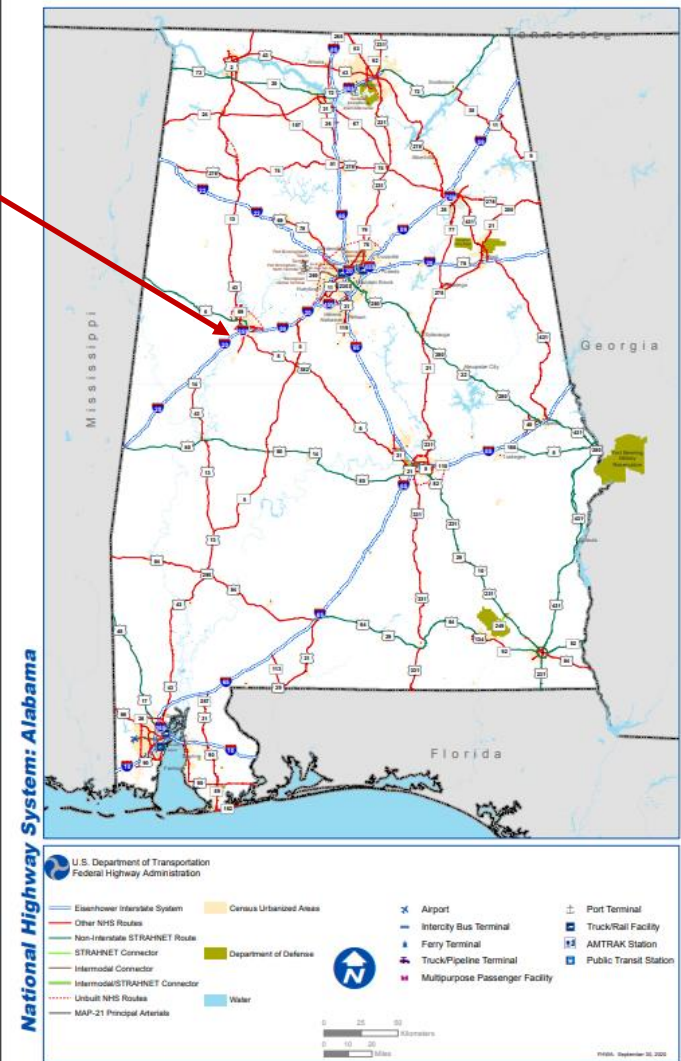
Oklahoma I-40, Caddo County



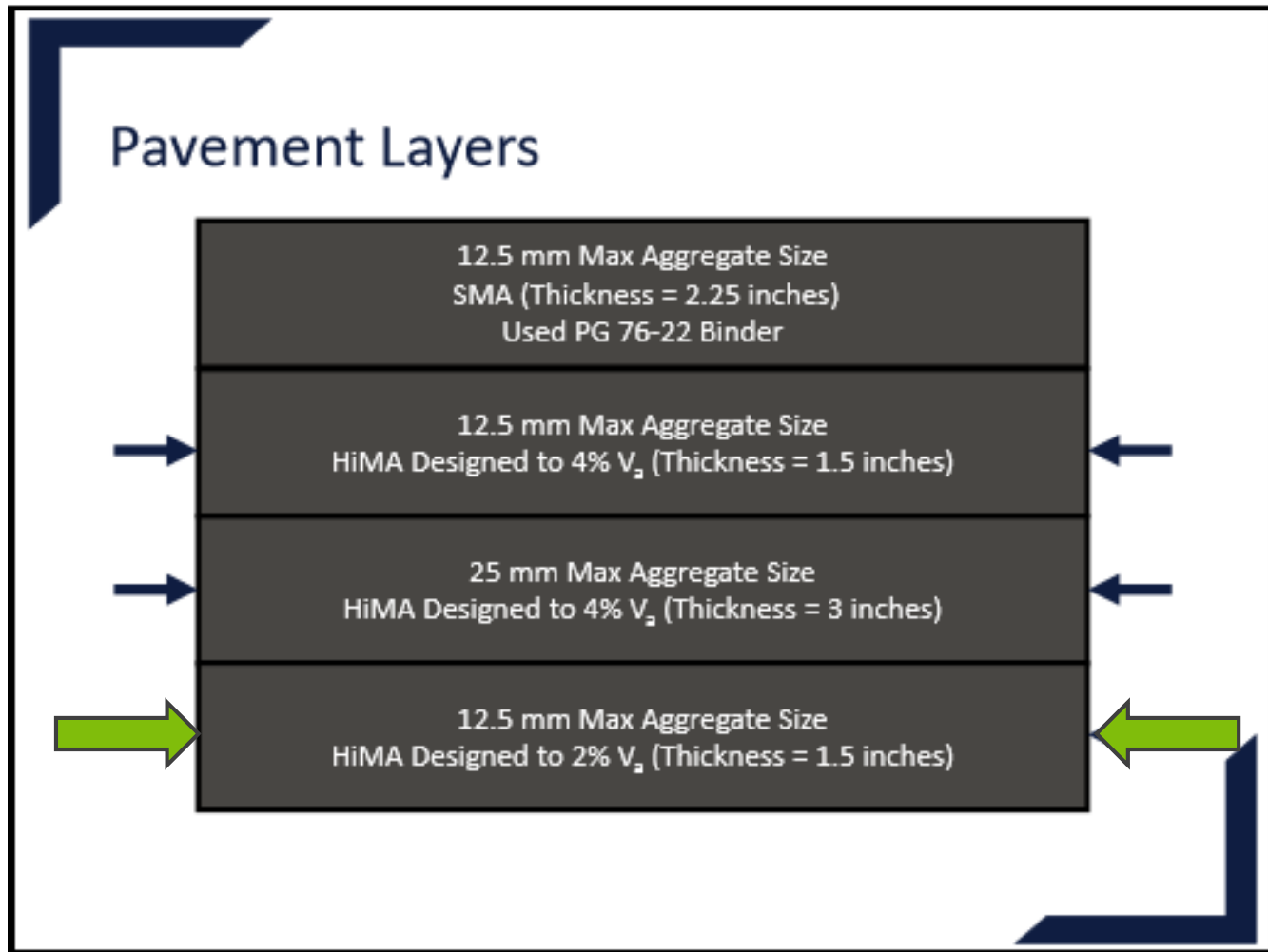
- Before rehab: high severity transverse cracks, rutting, very rough
- Rehabilitation: Feb-Apr 2012
- Practically no distress after 8+ years
- 2020 IRI: 55 in/mi (EB), 53 in/mi (WB)

I-59/20, Tuscaloosa Co., AL MP 62.0-68.4

- Opened in 1970, rehabilitated in 1983, 1990 and 2001
- Extensive longitudinal cracking
 - About 1/3 of cracks extended beyond the top 4 inches of pavement
 - Deflection (FWD) analysis suggested the need for additional pavement thickness
- Numerous bridges within project limits complicated things
 - Very costly to raise bridges to allow for additional structure
 - Estimated almost \$8.7 million just to raise bridge surfaces



Alabama I-59/20 Rehabilitation



From Braden Smith (Hunt Refining) at 2018 SEAUPG Meeting

Resurfacing/Thin Overlays

- Dense-graded HMA
 - More resistant to rutting, cracking, spalling, studded-tire wear
 - New York City, 1st Ave
 - Florida (US 90, US 41)
 - Anchorage, AK
- Open-Graded/Permeable Friction Courses
 - Extend the life of open-graded friction courses by 50% (TTI-led study for Florida DOT)
 - Provide OGFC/PFC mixtures that are much more resistant to raveling and cracking than when using other binders such as PG76-22 and asphalt-rubber (NCHRP 877, performed by NCAT)

Manhattan, 1st Avenue

1st Ave, 2013



1st Ave, 2019



- Used NJDOT “High Performance, Thin Overlay” as a guide specification
- Trial project in 2012, performance convinced NYCDOT to overlay 53 blocks on 1st Ave in 2013
- 1½ inches, placed over repaired JRCp, geotextile
- TR News Article, May/ June 2019 issue (<http://www.trb.org/Publications/Blurbs/179900.aspx>)
- In “good” condition, according to NYCDOT website

Florida-US 90 @ I-10 (Midway), Westbound Lanes

- Extends from a Pilot station south (east) of I-10, through the interchange to beyond the entrance to a Flying J truck stop
- Channelized truck traffic, stopping and turning into truck stop
- Planned to reconstruct with concrete pavement, but milled and replaced 2.5 inches of HMA using HP binder as a trial/stopgap measure



US 90 @ I-10, Midway



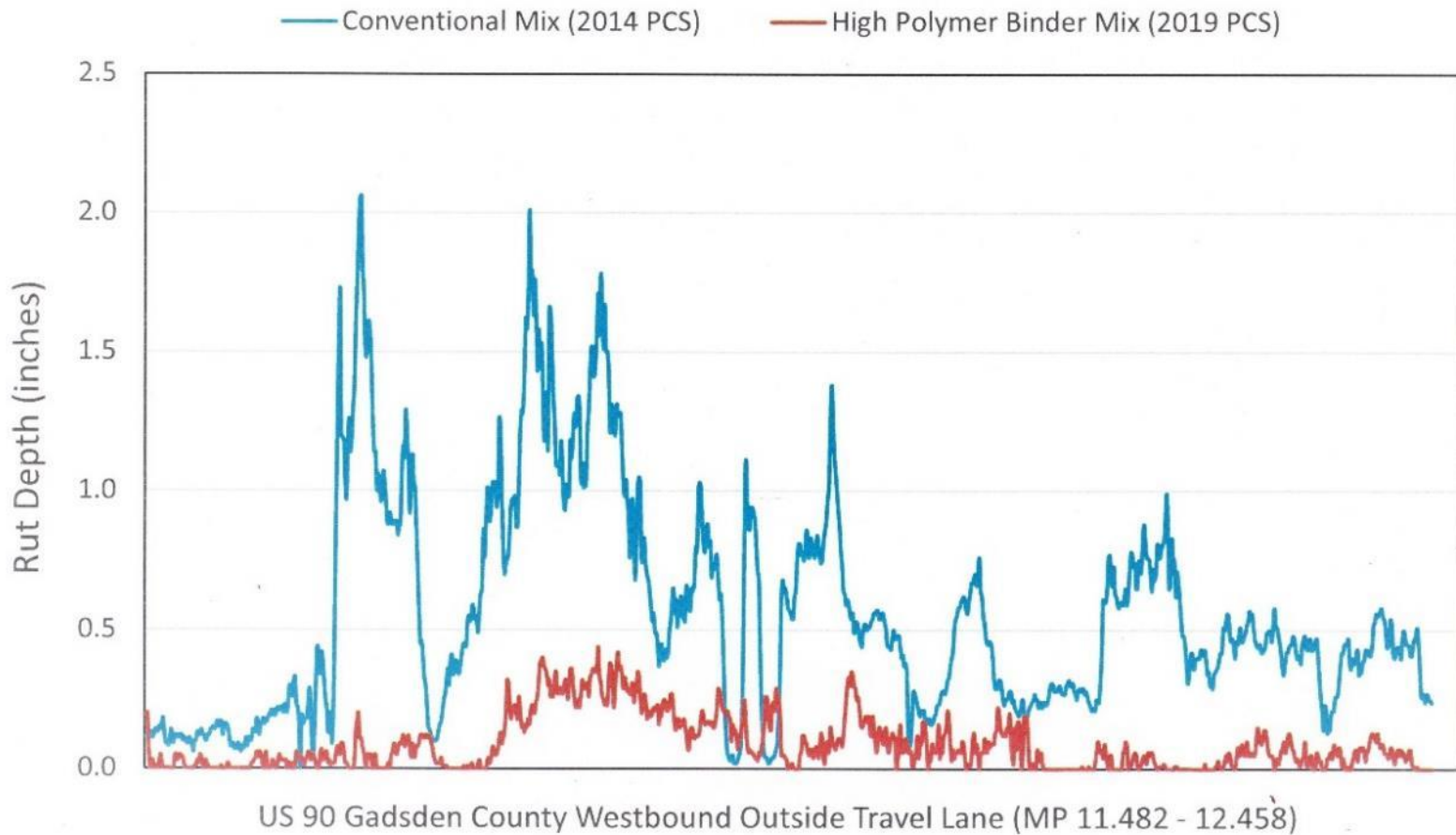
Looking east at turning traffic



Stop bar at traffic signal

FDOT Rutting Measurements, US 90

US 90 High Polymer Test Section Rut Data



Florida DOT

- Test section at ALF site at State Materials Office in Gainesville
- Additional trial projects in FL Panhandle where rutting had been a problema
- July 2017-adopted “High Polymer” binder grade as part of FDOT Standard Specifications, replacing PG82-22
- Research projects at UNR and TTI to evaluate AASHTO layer coefficient and OGFC performance
- Observed improvements in rutting and reflection crack performance compared to PG76-22 in overlay of JCP in Tampa (US 41)

PFC/OGFC

I-10, Gadsden Co.



US 17, Charlotte Co.



- Water flows in and through the layer, improving wet weather driving conditions
- For high speed traffic, porous layer greatly reduces air pumping and sound generated at the tire/pavement interface
- Shown to reduce TSS in storm water by 90% compared to surfaces with sheet flow, BMP for highway runoff water quality in Edwards recharge zone

Other States

- Alaska: mixtures using highly modified asphalt binder (PG64E-40) are shown to be more resistant to studded tire wear and are used where this has been an historical problem, especially around Anchorage
- New Jersey: bridge deck waterproofing surface course, binder-rich intermediate course mixtures
- Virginia: SMA and dense-graded mixtures, especially in overlays of jointed concrete on Interstate highways

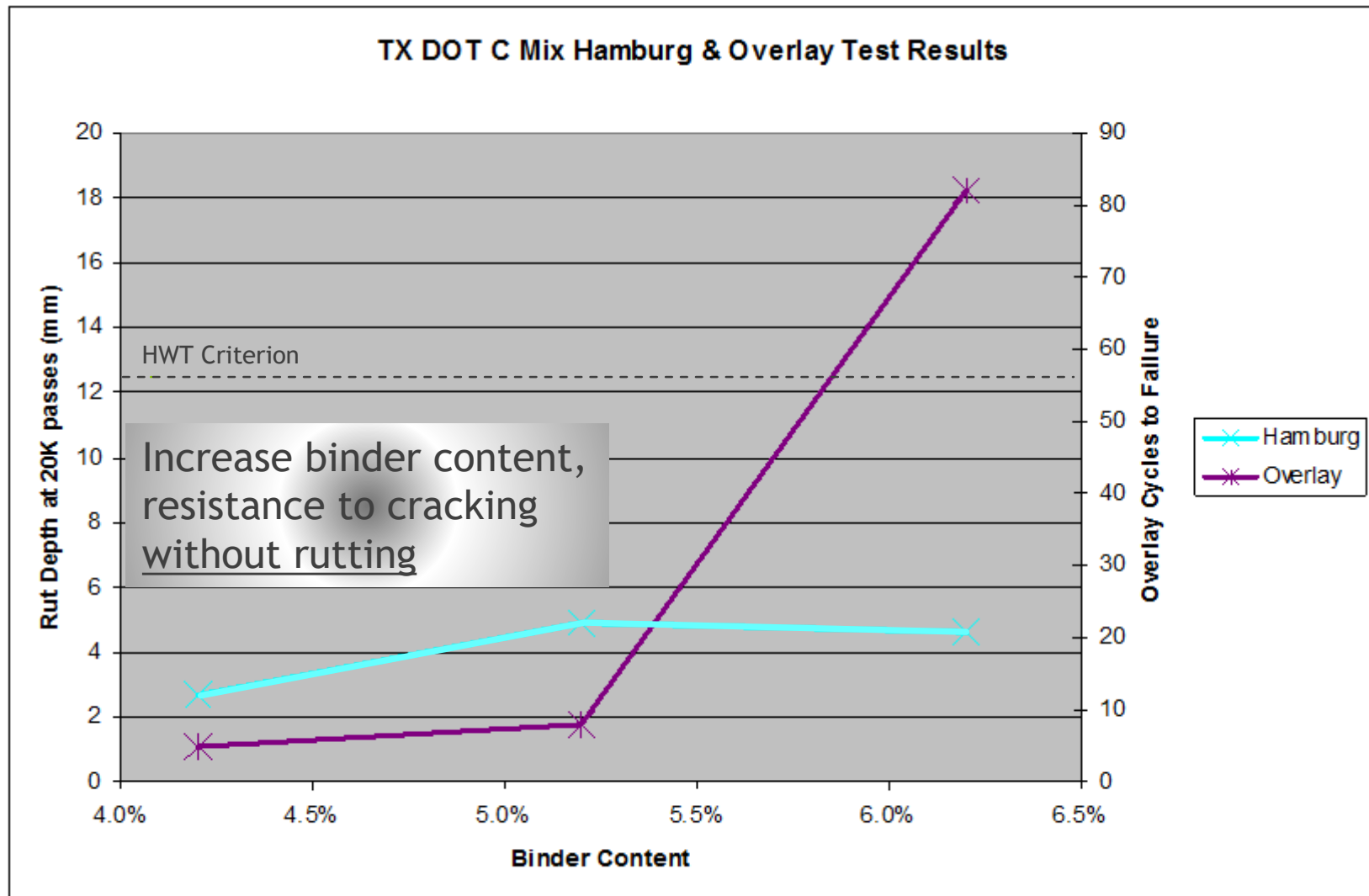
High Performance/Highly Modified Asphalt Binders: Best Uses

- Tougher, more durable wearing courses
 - Permeable Friction Courses, Thin Overlay Mixtures, SMA
- Upper lifts for pavements where 20 year design ESAL > 10 million
 - Perpetual pavements
- Deep rehabilitation due to overloads (oilfield, bus pads)
 - Ability to get in, get out, stay out in challenging construction and loading conditions
- Resilient pavement structures
- Low voids bridge deck surfaces

Optimized Mix Design

- Should prioritize meeting performance criteria, instead of mixture volumetric properties
 - Volumetric properties are important for production QC
- Performance-related testing, potential HP criteria (dense-graded mixtures):
 - Rutting/stripping: $\text{HWT} < 6 \text{ mm}$
 - Cracking:
 - Overlay test: $\text{Critical Fracture Energy} \geq 1.5 \text{ in-lb/in}$
 $\text{Crack Progression Rate} \leq 0.35$
- General-allow HMA producers latitude in binder selection
 - For example, could using HP binders allow the greater use of RAP or natural sand while still meeting performance criteria?
 - NJDOT does this for their high performance, thin overlay and bridge deck surfacing specifications

Example- TxDOT Item 341, Type C



LCCA-Agency Costs:

3.5% discount rate, 40 year analysis period

Roadway Classification	NPV-Agency Costs, \$ X 1000/mile		
	PG76-22	HP Binder, ΔHMA, Cost/ton	
		\$15.00	\$25.00
Rural Arterial	\$4,146.95	\$3,905.00	\$4,007.68
Urban Arterial	\$6,796.58	\$6,550.95	\$6,677.15
Limited Access	\$8,058.65	\$7,662.99	\$7,869.77

- Estimated net present value for project types assuming different asphalt mixture cost differences (per short ton) of hot mix asphalt
 - Accounted for difference in project costs assuming different mixture cost differentials
 - Typical difference: \$15-25/ton depending on mix type
- HP mixture is cost-effective due to increase in service life

FHWA “Every Day Counts” Initiative

- Targeted Overlay Pavement Solutions
- Solutions for integrating innovative overlay procedures into practices that can improve performance, lessen traffic impacts, and reduce the cost of pavement ownership.
- Approximately half of all infrastructure dollars are invested in pavements, and more than half of that investment is in overlays. By enhancing overlay performance, State and local highway agencies can maximize this investment and help ensure safer, longer-lasting roadways for the traveling public.

State of the Practice

Recent improvements to design methods, interlayer technology, slab geometry, and concrete mixtures have broadened concrete overlay surface treatment applicability, reliability, sustainability, and cost-effectiveness. A joint effort by Georgia, Iowa, Kansas, Michigan, Minnesota, Missouri, North Carolina, and Oklahoma resulted in the development of an improved design procedure for jointed unbonded concrete overlays on either concrete or composite pavements.

For asphalt overlays, several State departments of transportation (DOTs) have adopted SMA due to increased service life and performance. The Maryland, Alabama, and Utah DOTs each used over 1 million tons of SMA during a 5-year period. DOTs in Florida, Georgia, New Jersey, New York City, Tennessee, and Virginia found highly modified asphalt in thin overlays is more resistant to reflective cracking. It has increased pavement life by two to four times for DOTs in Alabama and Oklahoma.

The screenshot displays the FHWA Center for Accelerating Innovation website. At the top, there is a navigation bar with links for 'About', 'Programs', 'Resources', 'Briefing Room', 'Contact', and 'Search FHWA'. Below this is a search bar and a secondary navigation bar with links for 'CAI Home', 'Every Day Counts', 'STIC Network', 'AID Demonstration', 'AMR Program', and 'Resources'. The main header features the 'Every Day Counts' logo with the tagline 'Innovation for a Nation on the Move'. Below the header is a row of five images: a construction worker, a tablet displaying a map, a construction site, a worker with a tablet, and a road with traffic cones. The main content area is titled 'EDC-6 Innovations (2021-2022)' and contains three sections: 'Crowdsourcing for Advancing Operations', 'e-Ticketing and Digital As-Builts', and 'Next-Generation TIM: Integrating Technology, Data, and Training'. To the right of these sections is a 'Contact' section with a link to 'View list of EDC-6 contacts' and a list of 'EDC Rounds' from 2011 to 2020. At the bottom right, there is a 'Return to top' link.

U.S. Department of Transportation
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CAI Home Every Day Counts STIC Network AID Demonstration AMR Program Resources

Every Day Counts
Innovation for a Nation
on the Move

EDC-6 Innovations (2021-2022)

Crowdsourcing for Advancing Operations
Crowdsourced data can be obtained whenever and wherever people travel, allowing agencies to capture in real time what happens between sensors, in rural regions, along arterials, and beyond jurisdictional boundaries. Agencies at all levels can use crowdsourced data integrated from multiple streams to optimize roadway use for reduced congestion and increased safety and reliability.

e-Ticketing and Digital As-Builts
Converting paper-based materials ticketing systems and as-built plans into electronic (e-Ticketing) workflows and digital as-builts enhances the accessibility of highway project data. e-Ticketing improves the tracking, exchange, and archiving of materials tickets. Digital information, such as 3D design models and other metadata, enhances the future usability of as-built plans for operations, maintenance, and asset management.

Next-Generation TIM: Integrating Technology, Data, and Training
Traffic Incident Management (TIM) programs aim to shorten the duration and impact of roadway incidents and improve the safety of motorists, crash victims, and responders. New tools, data, and training mechanisms are available that can benefit both new and existing TIM programs, including local agency and off-interstate applications.

Strategic Workforce Development
The demand for highway construction, maintenance, and operations workers is growing, while at the same time, emerging technologies require these workers to have new skills. The Highway Construction Workforce Partnership has developed new resources and innovative strategies for identifying, training, and placing individuals in the Contractors' workforce filling the construction jobs that support the Nation's highway system.

Targeted Overlay Pavement Solutions
Pavement overlays represent a significant portion of highway infrastructure dollars. State and local highway agencies can maximize this investment and help ensure safer, longer-lasting roadways by employing innovative overlay procedures that will improve pavement performance, lessen traffic impacts, and reduce the cost of pavement ownership.

UHPC for Bridge Preservation and Repair
Ultra-high performance concrete (UHPC) is a new material for bridge construction that has become popular for field-cast connections between prefabricated bridge elements. Bridge preservation and repair is an emerging and promising application for UHPC. UHPC-based repair solutions are robust, and offer superior strength, durability, and improved life-cycle cost over traditional methods. State and local agencies can deploy UHPC for bridge preservation and repair to maintain or improve bridge conditions.

Virtual Public Involvement
Public engagement during transportation project planning and development helps agencies identify issues and concerns early in the process, which can ultimately accelerate delivery. Virtual public involvement strategies supplement traditional face-to-face information sharing with technology platforms that increase the number and variety of methods agencies use to inform the public, receive feedback, and collect and consider comments.

Contact
View list of EDC-6 contacts

EDC Rounds
EDC-1 (2011-2012)
EDC-2 (2013-2014)
EDC-3 (2015-2016)
EDC-4 (2017-2018)
EDC-5 (2019-2020)

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We bring you the best pavement experience through cutting-edge bitumen modification, pavement design and construction support for a range of paving applications.

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- Pioneered SBS bitumen modification
- Has over 40 years of experience implementing SBS in paving applications
- Authored numerous patents related to styrenic block copolymer technologies
- Continuously innovates expanding the technology portfolio
- Reaches Americas, Asia, Africa, Australia and Europe

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