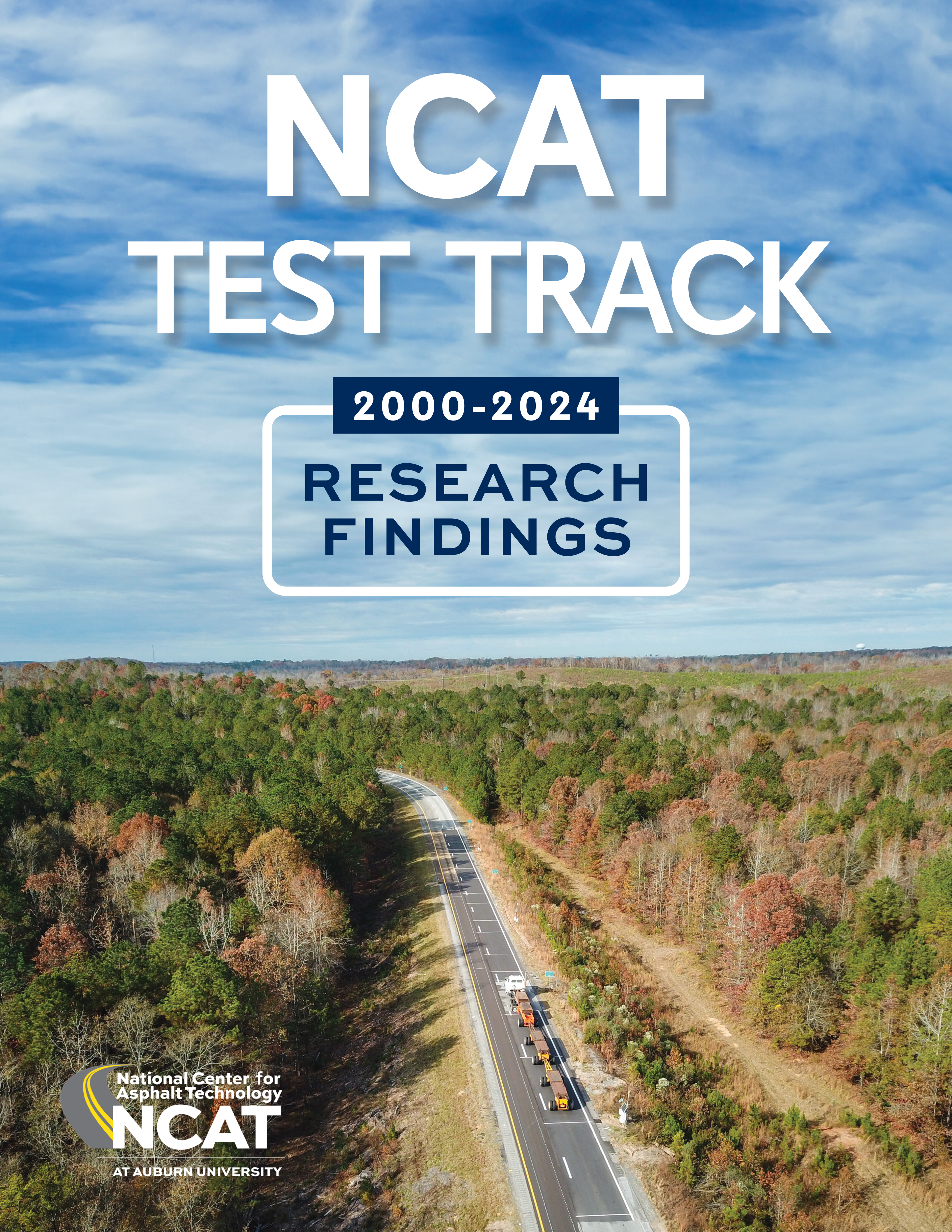


NCAT TEST TRACK

2000-2024

RESEARCH FINDINGS

National Center for Asphalt Technology
NCAT
AT AUBURN UNIVERSITY

CONTENTS

CAPABILITIES

The NCAT Test Track is a national research proving ground for asphalt pavements. This real-world laboratory allows for cutting-edge pavement experimentation while avoiding the risk of failure on actual roadways.

The NCAT Test Track is a world-renowned accelerated pavement testing facility that combines full-scale pavement construction with heavy truck trafficking for rapid testing and analysis of asphalt pavements. It is the only facility in the United States that simultaneously tests instrumented pavements under real environmental conditions with accelerated loading.

Since its original construction in 2000, findings from this unique facility have helped improve specifications for aggregates, asphalt binders, additives, and asphalt mix designs, as well as more cost-effective asphalt pavement design, construction, and preservation methods.
The research will continue to pay dividends for years to come.

OVERVIEW

Located on a 309-acre site, the Test Track is a 1.7-mile oval comprised of forty-six 200-foot test sections sponsored on three-year research cycles. The track is funded as a cooperative project among highway agencies and industry sponsors with specific research objectives for their sections and shared goals for the asphalt industry.

Test sections are commonly classified as structural experiments, surface mix experiments, or pavement preservation studies. At the end of each research cycle, test sections either remain in place for additional trafficking and evaluation in the next cycle or are replaced with new research.

Structural pavement sections have varying thicknesses that closely resemble real-world highway pavements. They have embedded strain and pressure sensors to evaluate real-time pavement response to loads to validate mechanistic-empirical pavement design models. Surface mix performance sections are built on a robust cross-section that limits distress to the experimental surface layers. Pavement preservation treatments are applied to existing sections to determine the life-extending benefits of these treatments.

In 2015, a partnership with the Minnesota Department of Transportation's Road Research Facility (MnROAD) was established to address asphalt pavement research needs in northern and southern climates. Companion pavement sections were built at MnROAD and the Test Track to evaluate asphalt additives and mixture cracking tests. The partnership also included pavement preservation experiments to quantify the life-extending benefits of pavement preservation on both low- and high-volume roadways. Findings from the NCAT-MnROAD pavement preservation experiments are summarized in another report.

This document summarizes key Test Track findings through the eighth research cycle and their implementation into agency specifications and industry practices.

RESEARCH CYCLES

Each Test Track research cycle consists of three phases. The first begins with building or replacing test sections, the second involves trafficking, data collection, and laboratory testing, and the third phase focuses on forensic evaluations.

PHASE ONE

Test sections are built and/or replaced, which takes approximately six months. Mixture samples from construction are obtained for laboratory testing.

PHASE TWO

Each section is subjected to 10 million equivalent single-axle loads (ESALs) of heavy truck traffic applied over two years. Their performance is monitored throughout this phase.

PHASE THREE

Forensic analyses are conducted on damaged sections to determine the contributing factors to pavement distress. This can include destructive evaluation, such as trenching and coring.

FIRST CYCLE (2000-2003)

The first cycle began with 46 newly constructed test sections. The only variables were the properties of asphalt mixtures in the top four inches. This cycle was completed after 10 million equivalent single axle loads (ESALs) were applied, which is two to four times the load interstate heavy highways carry in two years.

SECOND CYCLE (2003-2006)

Structural experiments were conducted in the second cycle to examine issues relating to mechanistic-empirical pavement design. Eight sections were completely removed to the subgrade and reconstructed to evaluate different layer thicknesses. Some structural sections used modified asphalt binders, and others used neat asphalt binders. Each structural section was built with embedded stress and strain gauges to continually measure the pavement response to traffic loading. In addition, 14 sections were milled and overlaid with a new surface mix, and the remaining 24 were left in place to evaluate the effects of additional traffic and environmental exposure on their long-term durability and performance.

THIRD CYCLE (2006-2009)

Twenty-two new sections (15 for mix performance evaluation and 7 for structural evaluation) were built for the third cycle. Eight original surface mix performance sections from the first cycle remained in place and accumulated a total of 30 million ESALs by the end of the third cycle. Sixteen sections from the second cycle (twelve mix performance and four structural) remained in place and accumulated a total of 20 million ESALs. A new warm mix asphalt (WMA) section was built late in the cycle.

FOURTH CYCLE (2009-2012)

Twenty-five new sections were built for the fourth research cycle. By the end of the cycle, three of the original surface mix performance sections remaining from the first cycle accumulated 40 million ESALs, nine sections remaining from the second cycle accumulated 30 million ESALs, and nine sections remaining from the third cycle accumulated 20 million ESALs. Six agencies co-sponsored the Group Experiment, a collection of test sections with a common cross-section to assess the performance and structural response of pavements constructed with warm-mix technologies (WMT), high reclaimed asphalt pavement (RAP) contents, a combination of high-RAP content and WMT, and a porous friction course containing 15% RAP.

FIFTH CYCLE (2012-2015)

The 2012 Track featured a more complex range of experiments than any of the previous cycles. Of the 46 total sections, 22 were new, 14 were left in place from the fourth cycle (including the Group Experiment sections), six were left in place from the third cycle, three remained from 2003, and two remained from the first cycle. The Green Group Experiment began in the fifth cycle to evaluate the performance and structural responses of test sections optimizing the use of WMA and recycled materials. Other research included porous friction courses (PFCs) and cold central plant recycling (CCPR) mixes. Eight new PFC test sections and one remaining PFC section were tested. Three new structural sections were constructed to evaluate CCPR as a base layer.

SIXTH CYCLE (2015-2018)

The 2015 research cycle consisted of two sections from 2000, one surface mix performance section from 2003, three from the 2006 high RAP experiment, three from 2009 with crack seals and high friction surfaces, 18 from the 2012 cycle, and 19 new sections. Of the 19 new sections, nine were removed to the aggregate base layer and replaced with new asphalt structures. Seven were instrumented for the Cracking Group Experiment to identify which laboratory tests best correlate with the field top-down cracking performance. This experiment also expanded the partnership with MnROAD by building complementary test cells on the I-95 test road in Minnesota to identify the best lab tests and criteria for assessing resistance to thermal cracking. The other 10 new sections included four surface mix performance sections, four pavement preservation sections with chip seals, and two sections with high friction thinlays and microsurfacing.

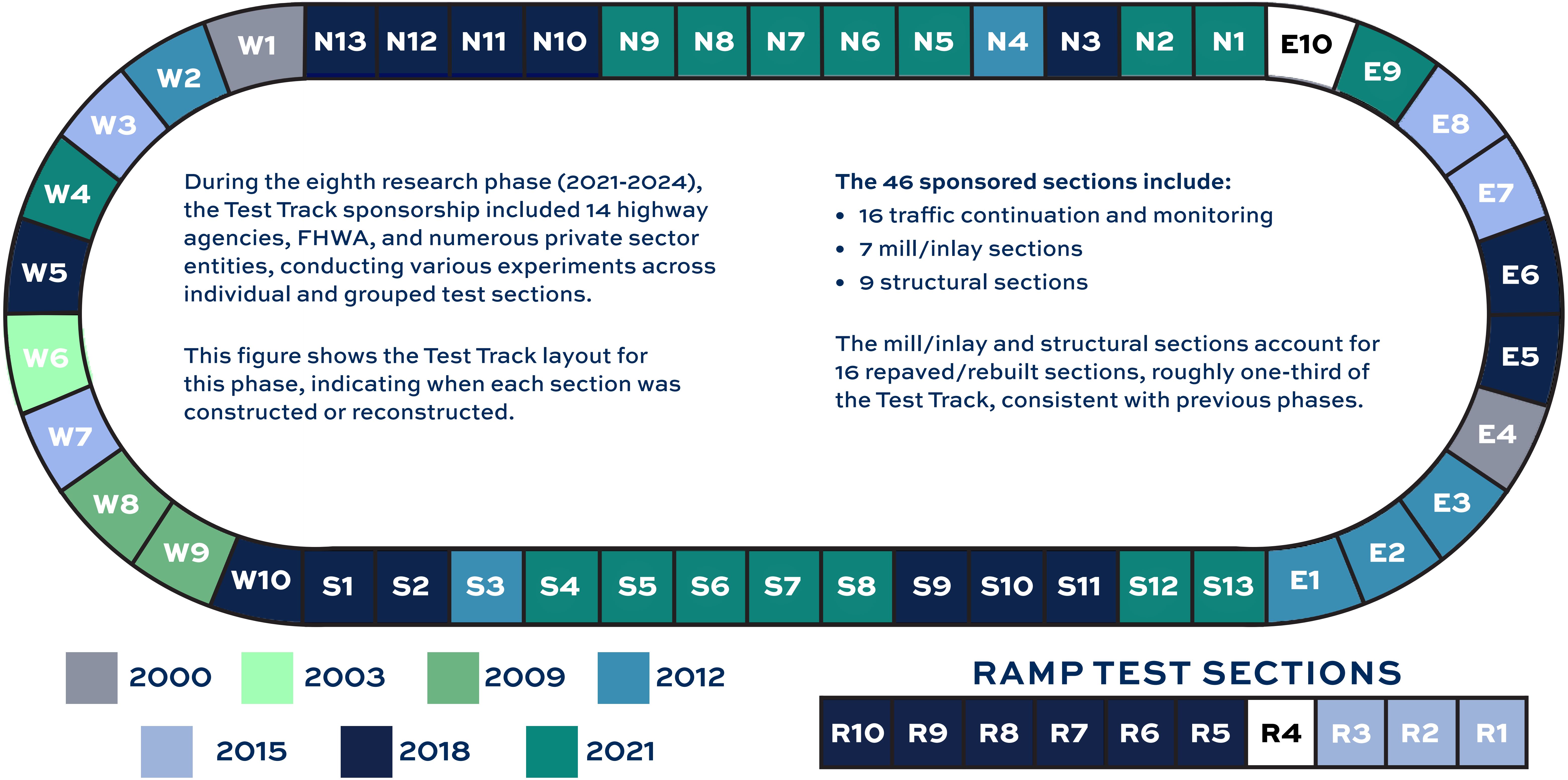
SEVENTH CYCLE (2018-2021)

The seventh cycle continued to evaluate mixture cracking tests and pavement preservation treatments in collaboration with MnROAD, with new experiments focused on balanced mix design (BMD) and asphalt rejuvenators. Eighteen sections were resurfaced or rebuilt for new experiments, and 28 sections remained in place for continued evaluation, including two sections from original construction in 2000. Experiments featured OGFC mixtures, bio-based spray-on and mix rejuvenators, interlay treatments to reduce reflection cracking, surface friction, mix designs to improve longitudinal joints, thick-lift paving, and the impacts of lime and cement-stabilized foundation layers on pavement structural response under heavy loading and seasonal environmental conditions.

EIGHTH CYCLE (2021-2024)

The eighth cycle included 17 new test sections and 17 sections from previous cycles. Existing test sections featured BMD, reflection cracking treatments, bio-based spray-on and mix rejuvenators, thick lift paving, stabilized subgrade and base layers, cold-recycled RAP base layers, and in-place density. New test sections were built to evaluate BMD, the performance impacts of tack coat, surface friction, and the new Additive Group experiment featuring the fatigue cracking performance of asphalt mixtures modified with synthetic fibers, recycled plastics, and recycled tire rubber. Companion Additive Group experiment test cells were built at MnROAD in 2022 with a research focus on reflective and thermal cracking performance. This cycle was also the first to include experiments on the Test Track's off-ramp. Late in the cycle, trafficking eclipsed a significant milestone with the accumulation of 11 million miles driven by the Track's fleet of five trucks.

EIGHT CYCLES AND COUNTING



During the eighth research phase (2021-2024), the Test Track sponsorship included 14 highway agencies, FHWA, and numerous private sector entities, conducting various experiments across individual and grouped test sections.

This figure shows the Test Track layout for this phase, indicating when each section was constructed or reconstructed.

The 46 sponsored sections include:

- 16 traffic continuation and monitoring
- 7 mill/inlay sections
- 9 structural sections

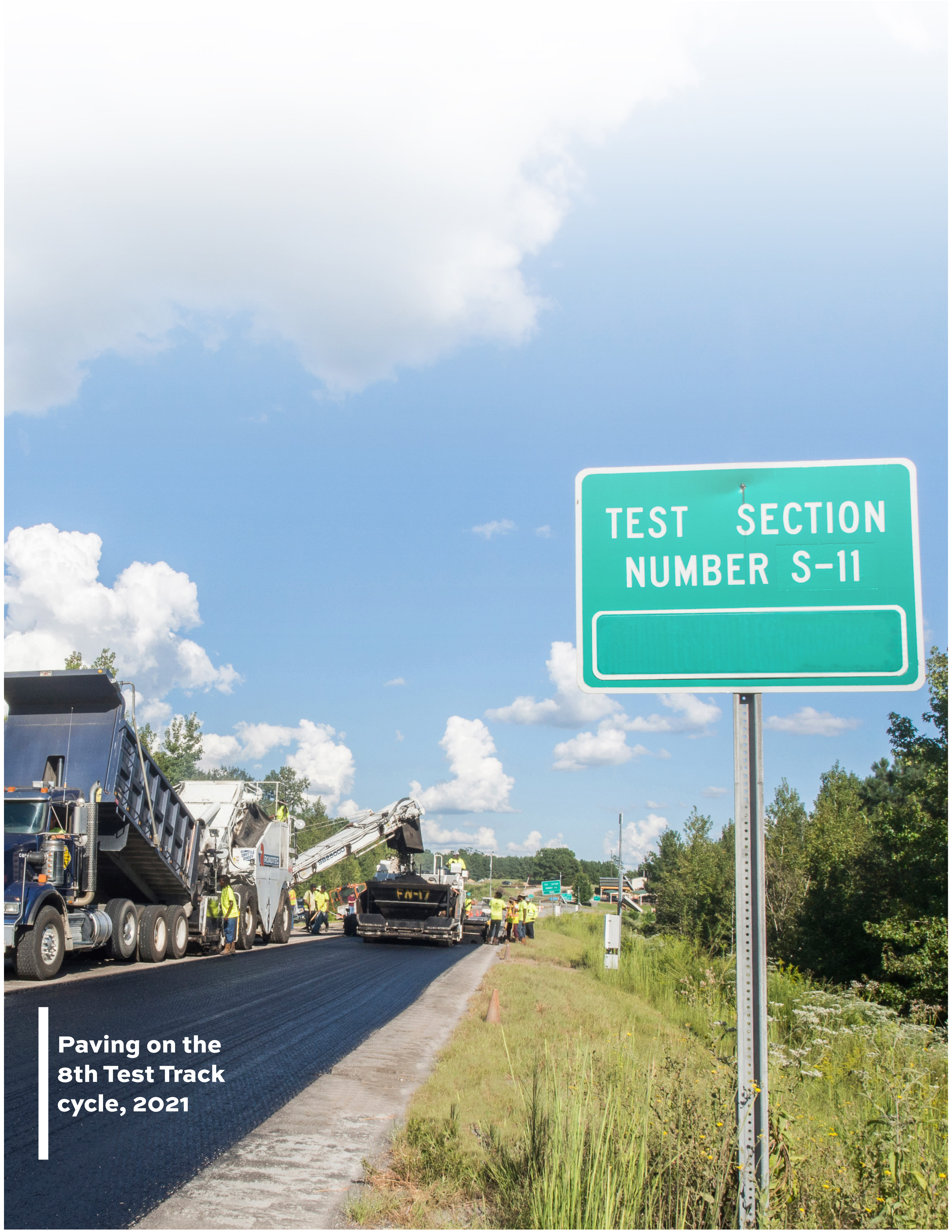
The mill/inlay and structural sections account for 16 repaved/rebuilt sections, roughly one-third of the Test Track, consistent with previous phases.

KEY FINDINGS

The focus of the Test Track is on practical research that will lead to improved specifications, construction methods, and design procedures. These key findings can be categorized into seven areas.

1. BALANCED MIX DESIGN
2. MIX DESIGN
3. AGGREGATE PROPERTIES
4. BINDER CHARACTERISTICS
5. STRUCTURAL PAVEMENT DESIGN AND ANALYSIS
6. TIRE-PAVEMENT INTERACTION
7. ADDITIONAL FINDINGS

Scan here *for all Test Track Reports*



Paving on the 8th Test Track cycle, 2021

1 BALANCED MIX DESIGN

1.1 BALANCED MIX DESIGN (BMD) EXPERIMENTS

BMD presents a new era of asphalt mix design and acceptance system to improve the quality of asphalt mixtures using laboratory mechanical/performance tests while allowing innovations in material selection and production optimization for economics and sustainability. Over the past two cycles of the Test Track, 10 test sections with various BMD research focuses were built under the sponsorship of the Kentucky, Oklahoma, Tennessee, and Texas DOTs and Cargill. These sections covered asphalt mixtures designed with a wide range of component materials, different BMD approaches per AASHTO PP 105, and different specification requirements for mixture volumetric, performance, and friction properties. Laboratory testing showed that all BMD mixtures, including those with 30% to 45% RAP, recycling agents, dry recycled tire rubber, and relaxed volumetric properties, had balanced rutting and cracking resistance.

These findings were supported by the excellent field performance of the test sections under accelerated pavement testing at the Test Track, highlighting the potential of BMD to extend the life span of asphalt pavements by improving the quality of asphalt mixtures.

The Texas DOT sections from the seventh cycle present a valuable case study demonstrating the pavement life extension benefit of BMD for asphalt overlay applications. The BMD section significantly outperformed the volumetric control section in the field cracking performance, providing a conservatively estimated life extension for 5.5 million ESALs of heavy traffic, as shown in Figure 1. The extended pavement life of the BMD section over the volumetric control section provided significant economic and environmental benefits from the “cradle-to-grave” life-cycle cost analysis and life-cycle assessment perspectives.

For more information, see NCAT Reports 24-02, Ch. 7, 10, 13, 14, and 18 and 21-03.

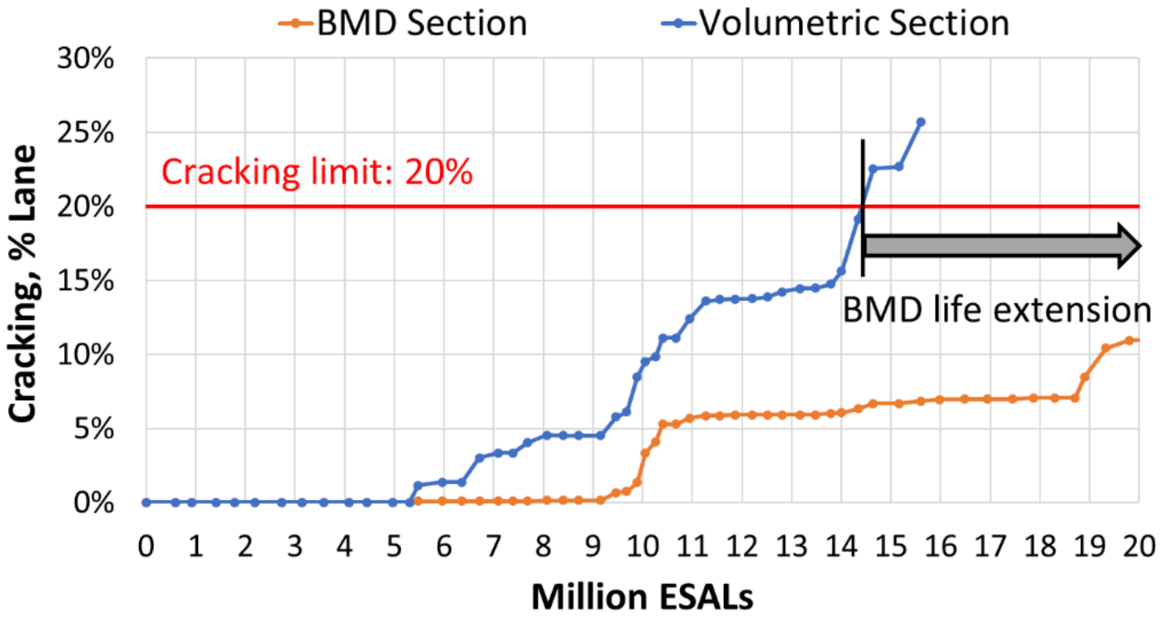


Figure 1. Field Cracking Performance of Texas BMD Section versus Volumetric Control Section.

1.2 CRACKING TESTS

With increased interest in BMD and performance tests, 11 state DOTs and the FHWA co-sponsored the Cracking Group experiment in the sixth research cycle. Seven sections constructed with varying surface mixtures using the same pavement structure underwent evaluation with seven laboratory cracking tests to gauge their correlation to top-down cracking performance on the Test Track.

The relatively thin construction of the test sections aimed to induce significant deflections in the asphalt layers due to heavy loading on the Test Track. Highly modified asphalt binder in the intermediate and base layers helped prevent bottom-up fatigue cracking. Consistent mix designs were applied to the lower two layers across all sections to facilitate a comparison of top-down cracking performance without confounding results from differing supporting conditions.

After six years of research and analysis across two cycles, variation in top-down cracking among the seven test sections highlights the critical role of surface mixture properties. Key conclusions from the seven cracking tests are as follows:

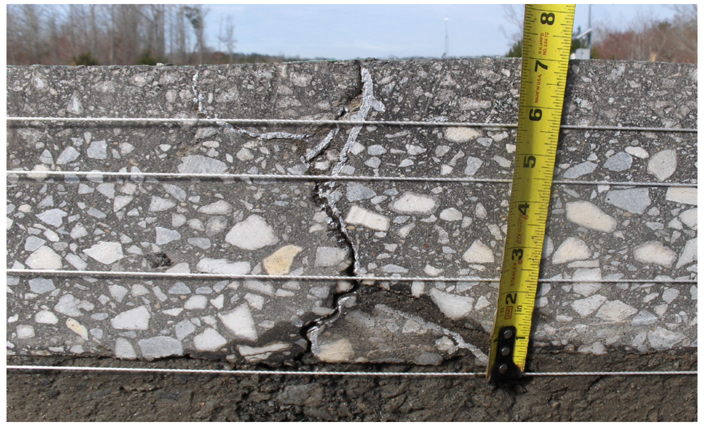


Figure 2. Example of Fatigue Cracking.

Contact Fan Yin at f-yin@auburn.edu for more information about the research in 1.1 and 1.2.

- The NCAT-modified version of the overlay test exhibited a good correlation with top-down cracking resistance, with faster testing times and lower coefficient of variation compared to the Texas procedure, though facing similar challenges in sample preparation and equipment costs.
- The Louisiana SCB test failed to distinguish mixtures by top-down cracking performance on the Test Track and is hindered by lengthy specimen preparation and misalignment with standard variability methods.
- The flexibility index showed a fair correlation with top-down cracking performance, albeit with reduced statistical discrimination due to high variability and similar challenges in specimen preparation as the Louisiana SCB test.
- The AMPT cyclic fatigue test index, Sapp, correlated well with top-down cracking except in one gap-graded asphalt rubber section. However, sample prep challenges, high costs, and data complexity make it unsuitable for routine BMD use.
- The CTIndex from the IDEAL-CT is a strong indicator of resistance to top-down cracking, correlating well with field performance and distinguishing between mixtures. The IDEAL-CT method is suitable for everyday use in BMD, including quality assurance testing.

For more information, see NCAT Reports 21-03, Ch. 2 and 18-04, Ch. 2.

BALANCED MIX DESIGN

1.3 RUTTING TESTS

Although most state DOTs indicate rutting is virtually eliminated as a primary distress, there is still interest in identifying reliable laboratory tests to evaluate rutting performance. NCAT has conducted repeated load tests, wheel-tracking tests, and rapid strength tests through each cycle to determine if laboratory test results correlate with rutting measured on the Track.

The Asphalt Pavement Analyzer (APA) has consistently provided reasonable correlations with rutting performance. Based on a correlation between APA results and rutting in the third research cycle, an APA criterion of 5.5 mm was established for heavy traffic surface mixes for tests conducted per AASHTO T340. The APA data from the fourth cycle also correlated with rutting on the Track. The APA showed a reasonable correlation with field rutting (R2 = 0.70) after the data from two 50% RAP sections were removed.

The Hamburg wheel tracking test (HWTT) has been increasingly accepted in recent years, and numerous state DOTs now have Hamburg requirements for mix design approval. The test is considered a proof test for evaluating rutting and moisture susceptibility. Many state agencies have HWTT criteria adopted for their local climate and materials. A maximum rut depth of 12.5 mm at 20,000 wheel passes is a commonly used failure criterion. NCAT conducted the Hamburg test following AASHTO T 324 at 50°C on 18 mixtures from the fourth cycle. Results correlated reasonably well (R2 = 0.74)with rutting measurements on the Track, and none of the test sections had any evidence of moisture damage.

Figure 3. Hamburg Wheel Tracking Test (HWTT).

The flow number (FN) test evaluates the rutting resistance of asphalt mixtures through cyclic repeated load compression. In the third cycle, NCAT employed a confined FN test with 10 psi confining stress and 70 psi repeated axial stress, revealing a strong correlation with track rutting. Recommended by NCHRP Report 673 and NCHRP Report 691, the FN test criteria (0 psi confining stress and 87 psi repeated axial stress) and traffic level thresholds were adopted in AASHTO T378. In the fourth research cycle, the FN test was conducted on 18 mixtures, showing a moderate correlation (R2 = 0.54) with field rutting after excluding data from sections with 50% RAP. All results in the study met AASHTO T378 FN criteria for 3 to 10 million ESALs of traffic.

Two new ‘rapid’ rutting tests, the High-Temperature Indirect Tension Test (HT-IDT ALDOT Method 458, Draft ASTM Standard) and the IDEAL Rutting Test (IDEAL-RT ASTM D8360) can be conducted on gyratory compacted specimens on the same day mix is produced. Each test requires only 45 minutes to 1 hour of conditioning time in a hot water bath, followed by a rapid strength test (less than 10 minutes for 3 replicates). During the 2021 Track, 14 unique mixes were tested using the rapid rutting tests at 50°C alongside the HWTT at 50°C and APA at 64°C. These mixtures were from multiple states containing various additives, binder types, binder contents, RAP contents, aggregate types, and aggregate gradations. None of these mixtures exhibited rutting failure on the Track and the results from the two rapid rutting tests correlated extremely well.

Both tests also showed a strong correlation with the HWTT test results. However, a good correlation was not observed between rapid rut tests and APA wheel tracking test results. Based on the correlation between the HT-IDT and HWTT, a threshold value of 20 psi for the HT-IDT is a reasonable pass/fail criterion for mixtures produced at the Test Track. The correlation between IDEAL-RT and HWTT suggests a minimum RT Index (IDEAL-RT Result) of 75 as a reasonable pass/fail criterion for mixtures produced at the Track. These criteria may be further refined in the future.

For more information, see NCAT Reports 09-08 and 12-10.

Contact Adam Taylor at tayloa3@auburn.edu for more information about the research in 1.3.

Figure 4a. High-Temperature IDT (HT-IDT) Test.

Figure 4b. IDEAL-RT Test.

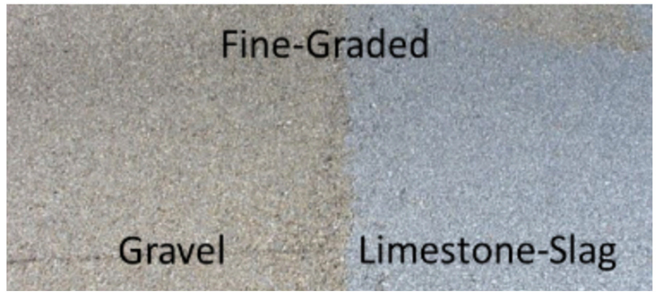
2 MIX DESIGN

2.1 FINE-GRADED VS. COARSE-GRADED MIXTURES

In the early years of Superpave implementation, there was an emphasis on coarse-graded mixtures to improve rutting resistance. However, that notion was called into question when the results of WesTrack showed that coarse-graded gravel mix was less resistant to rutting and fatigue cracking than fine-graded mixtures with the same aggregate.

In the first Test Track cycle, the issue of aggregate gradation was examined more completely. Twenty-seven sections were built with various aggregate types to compare coarse, intermediate, and fine-graded mixtures. Fine-graded Superpave mixes perform as well as coarse and intermediate mixes under heavy traffic, are easier to compact, and are less prone to segregation and permeability. While friction tests showed no consistent advantage between gradations, fine gradations resulted in lower tire-pavement noise. Consequently, many state highway agencies have updated specifications to include more fine-graded mix designs.

For more information, see NCAT Report 06-05, Ch. 3



2.2 HIGH-RECLAIMED ASPHALT PAVEMENT (RAP) MIXTURES

For nearly two decades, Test Track experiments have evaluated high-RAP content mixtures, providing practical insights into achieving good performance with economic and sustainability advantages. These studies support the slow but steady increase in the maximum RAP content permitted by state DOTs and helped move the national average RAP content of 16.2% in 2009 to 21.9% in 2021.

Figure 6. RAP Stockpile.

Numerous Test Track experiments have evaluated high-RAP content mixtures. The first involved six overlay moderate and high-RAP mix test sections built in 2006 that were trafficked for six years and 20 million ESALs. The softer virgin binder (PG 52-28) provided better resistance to raveling and top-down cracking. The study also concluded that using a polymer-modified virgin binder provided no benefit for rutting or cracking for mixes containing 20% or 45% RAP.

The second high-RAP experiment began in 2009 and used 50% RAP volumetric mix designs in each pavement layer. This was the first "group experiment" and featured four comparison sections, including 50% RAP HMA, 50% RAP WMA, virgin HMA, and virgin WMA. The 50% RAP HMA test section had no distresses at the end of two cycles and outperformed all other sections in the experiment in all performance measures, including fatigue cracking.

The Cracking Group experiment featured an interesting comparison of moderate and high-RAP content mixtures from 2015 to 2021. The experiment's control mix was a conventional 20% RAP Superpave mix with a PG 67-22 binder. One of the other test sections used the same aggregate and RAP sources as the control mix but increased the RAP content to 35% and used a softer PG 64-28 virgin binder.

Contact Randy West at westran@auburn.edu for more information about the research in 2.1 and 2.2.

After two cycles of trafficking and environmental exposure, the 35% RAP mix had only 1% lane area cracking compared to 45% lane area cracking for the control.

Other moderate and high-RAP experiments have been evaluated on the Test Track for DOTs in Mississippi and Florida. Cargill and Collaborative Aggregates have also sponsored Test Track evaluations of their bio-based rejuvenators for high-RAP mixtures.

The Test Track has demonstrated that high-RAP content mixtures can perform equal to or better than virgin and low-RAP content mixtures. NCAT strongly recommends using Balanced Mix Design tests with relaxed legacy criteria for high-RAP mix design approval and quality assurance testing.

For more information, see NCAT Reports 09-08 (pp. 17-21), 12-10 (pp. 40-51), 16-04 (pp. 35-65, 199-205) and 21-03 (pp. 32-75, 90-114, 116-125, 149-160).

MIX DESIGN

2.3 STONE-MATRIX ASPHALT (SMA) MIXTURES

Through the first three cycles of the Track, 19 SMA sections were put to the test (eight in 2000, eight in 2003, and three in 2006). The performance of these sections in the first cycle prompted several states to adopt this premium mix type for heavy traffic highways. Mississippi, Missouri, and Georgia DOTs then used the Test Track to evaluate lower-cost aggregates in SMA, which have helped make this mix type more economical.

An SMA mixture containing 12% ground tire rubber by weight of asphalt binder and an SMA with 5% recycled asphalt shingles (RAS) was successfully used in the 2012 Green Group Experiment. These two mixes did not contain the added fibers typically used with SMA and had no issues with binder draindown.

In 2018, the Alabama DOT used the Test Track to evaluate a 4.75 mm NMAS SMA as a thinlay treatment option for high volume roads. As of 2024, this mix has shown minimal rutting and cracking after 20 million ESALs of traffic.

For more information, see NCAT Reports 21-03 and 16-04

Contact Adam Taylor at tayloa3@auburn.edu for more information about the research in 2.3.

Figure 7. Close-up of aggregate skeleton of an SMA mix.

2.4 WARM-MIX ASPHALT (WMA) MIXTURES

Warm Mix Asphalt (WMA) represents a group of technologies that allow a reduction in the temperatures used for producing and placing asphalt mixtures. At the end of the second research cycle, an early version of MeadWestvaco's (Ingevity) Evotherm® technology was used in overlays to repair two test sections with extensive damage. The sections were opened to traffic immediately after construction and remained in service throughout the third cycle with rutting performance comparable to hot mix asphalt (HMA) for 10.5 million ESALs and no cracking. One section was left in place at the start of the fourth cycle and endured more than 16 million ESALs before the test section was used for a different experiment. The performance of those sections was early evidence that WMA could sustain extremely heavy traffic.

In the fourth research cycle, WMA test sections were constructed as part of the Group Experiment. They aimed to compare pavement performance using two different WMA types (foaming and chemical additive) and combining high-RAP content with WMA against a control HMA section.

All sections were built on the same stiff subgrade with identical aggregate base and asphalt layers. After 10 million ESALs, no cracking was observed. By 20 million ESALs, cracking varied: 22% in the WMA foaming section, 15% in the WMA additive section, 6% in the high-RAP WMA section, and 10% in the control. Despite differences, all remained below the 25% failure threshold. Rutting performance was satisfactory, easing agency concerns about WMA implementation.

For more information, see NCAT Reports 12-10, Section 3.2 and 16-10, Section 2.1.

Contact Carolina Rodezno at mcr0010@auburn.edu for more information about the research in 2.4.

MIX DESIGN

Contact Nam Tran at nam.tran@auburn.edu for more information about the research in 2.5.

2.5 DESIGN GYRATIONS

Results from the Test Track and data collected from various field projects across the United States as part of NCHRP Project 9-29 have shown the gyratory compaction effort specified in AASHTO standards was too high. High numbers of design gyrations (N_{design}) tend to grind aggregate particles and break them down much more than what occurs in pavements during construction or under traffic. Mix designers often used coarse-graded mixes to meet volumetric mix design criteria. However, these mixes are more challenging to compact and are more permeable, which can lead to durability issues. Asphalt mixtures on the Test Track were typically designed with N_{design} ranging from 50 to 70 using the Superpave gyratory compactor (SGC) and performed exceptionally well under heavy loading. As a result, many states have significantly reduced their levels.

Additionally, using coarse-graded asphalt mixtures designed at high N_{design} can also make compaction more challenging at the longitudinal joint, making it more permeable and susceptible to freeze-thaw damage. In addition to improving compaction practices, the Kentucky Transportation Cabinet (KYTC) also explored the potential use of a fine-graded mixture with a lower N_{design} of 65. This mixture was compared to a previously KYTC-approved coarse-graded mixture designed with a higher N_{design} of 100 in two adjacent sections. The longitudinal joints of these sections were constructed following standard practices. Field permeability tests showed the fine-graded mixture was 20% less permeable than the coarse-graded mixture, making the joint less susceptible to potential moisture and freeze-thaw damage. After 20 million ESALs, no cracking was observed, and rut depths were less than 5.5 mm. The section with the 100 gyrations mixture had 100% cracking at the joint, while the other section had 64%.

For more information, see NCAT Reports 09-08, Ch. 7 and 18-04, Ch. 8.

Figure 8. Superpave Gyratory Compactor (SGC) binder testing and specification.

Paving on the 8th Test Track cycle, 2021

MIX DESIGN

2.6 OPEN-GRADED FRICTION COURSE (OGFC)

More than 10 open-graded friction course (OGFC) mixtures, also known as porous friction courses (PFC), were placed on the Test Track during the first three research cycles. In general, all OGFC sections reduced water spray and tire-pavement noise while providing skid and rutting resistance. Many states started adopting OGFCs to improve wet weather driving visibility, as shown in Figure 9.

Typically, aggregate shape requirements for OGFC mixtures (flat and elongated) are based on European experience. Georgia DOT validated the feasibility of using coarse aggregates with a relaxed flat and elongated requirement in the third and fourth Test Track cycles.

State DOTs don't typically attribute any structural value to OGFC layers. However, the structural characterization of these sections indicated that OGFC contributed to the structural integrity of the section with a revised structural coefficient of 0.15 during the fourth Test Track cycle.

Delamination can significantly affect the longevity of OGFC mixtures and is due largely to construction practices and tack coat applications. Due to its high air void content, an OGFC mix has less contact area with the underlying receiving surface, so a heavier tack coat is needed to form an adequate bond. Two Florida DOT tack coat studies conducted in the fourth and fifth Test Track cycles evaluated several tack methods for improving OGFC performance. The same OGFC mix (PG 76-22 and 15% RAP) was placed at a thickness of 0.75 inches in each test section after a tack coat was applied. Results of these studies found that a thick polymer-modified tack coat (CRS-2P) applied with a spray paver at a target rate of 0.20 gal/yd_2 significantly improved OGFC performance. In addition, a non-tracking hot-applied polymer tack applied with a conventional distributor at a target residual rate of 0.15 gal/yd_2 can be considered an alternative to CRS-2P applied with a spray paver, depending on paving conditions.

Figure 9. Comparison of driver's view on rainy days on dense-graded mix (left) and OGFC mix (right).

OGFC mixtures are used in southern states to reduce wet-weather accidents. However, their use has declined due to premature raveling issues after approximately six or seven years in service. In the 2012 Test Track cycle, the Alabama DOT sponsored three OGFC sections to evaluate potential changes to evaluate potential changes to mix components to improve durability. One OGFC section used a smaller NMAS (9.5mm vs. 12.5mm.) Another section used synthetic fibers instead of cellulose fibers. The third section used ground tire rubber instead of fiber to mitigate draindown. The three OGFC mixtures had excellent perfomance through nine years and 30 million ESALs.

Contact Chen Chen at czc0105@auburn.edu for more information about the research in 2.6.

Laboratory and field performance results indicated these adjustments could improve the long-term performance of OGFC mixtures. In addition, the 9.5 mm mix is still permeable (0.03 cm/sec or 26m/day) after 20 million ESALs.

For more information, see NCAT Reports 24-01, Ch. 3, 21-03, Ch. 3, and 12-10, Ch. 2 and 3.

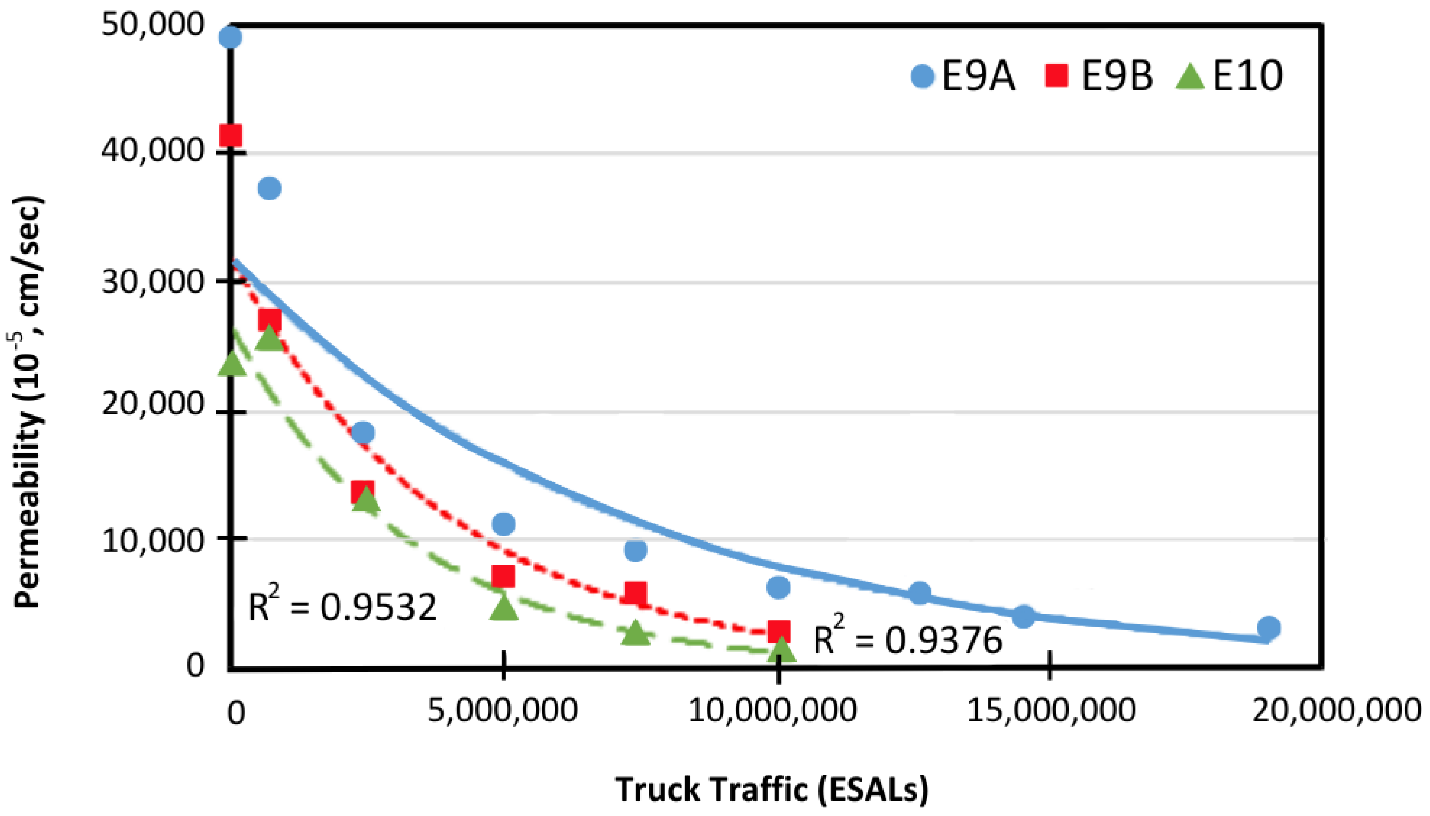


Figure 10. Field Permeability Performance.

3 AGGREGATE PROPERTIES

Contact Thomas Harman at tom.harman@auburn.edu for more information about the research in 3.1 and 3.2.

3.1 ELIMINATION OF THE RESTRICTED ZONE

The original Superpave mix design included a restricted zone within the gradation band for each nominal maximum aggregate size. However, the first Track cycle showed that mixtures with gradations through the restricted zone did not rut, leading to its removal from Superpave specifications.

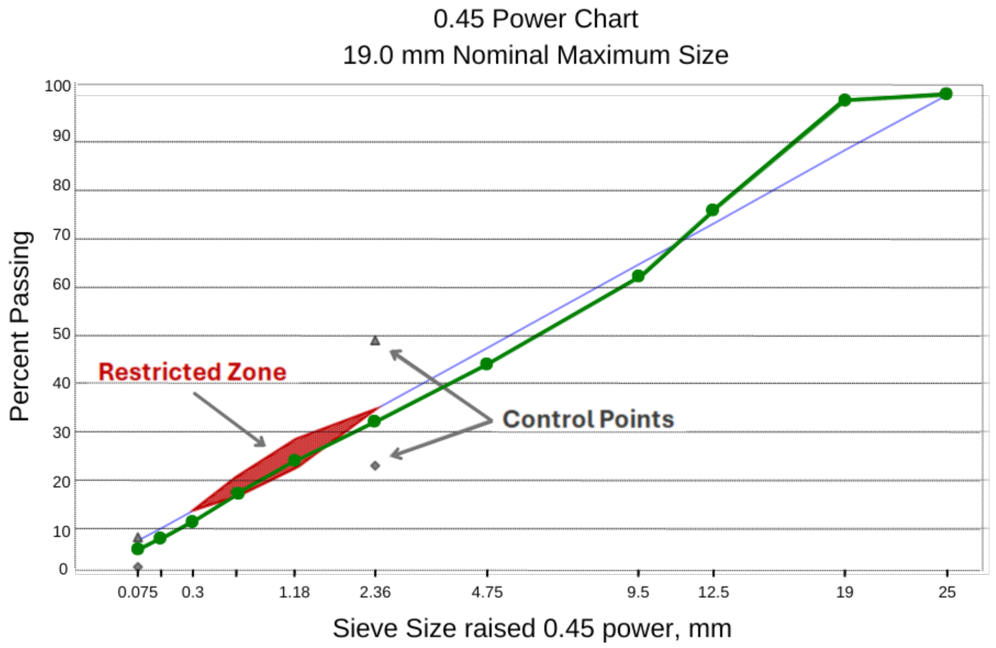


Figure 11. Example of a gradation violating the 19.00 mm Restricted Zone.

3.2 FLAT AND ELONGATED

Georgia DOT led the way in using SMA in the early 1990s and began modifying their OGFC mixes to resemble a coarser and thicker porous European-style mix. The strict aggregate shape limits for these mixes limited the available aggregate sources in Georgia and resulted in prices more than four times those of conventional coarse aggregates. They used the Test Track to evaluate using local aggregates with a less strict flat and elongated requirement for their OGFC mixes, and the lower-cost local aggregates improved drainage characteristics and didn't affect performance.

For more information, see NCAT Reports 17-03 and 02-12.

Figure 12. Flat and elongated test apparatus.

4 BINDER CHARACTERISTICS

Contact Nam Tran at nam.tran@auburn.edu for more information about the research in 4.1.

4.1 EVALUATION OF ALTERNATIVE BINDERS

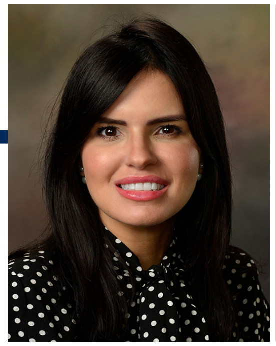
Three test sections were built in 2009 to evaluate the effectiveness of Trinidad Lake Asphalt (TLA) and Thiopave® pellets for use in asphalt mixes. TLA pellets are made from a natural asphalt source in Trinidad, while Thiopave® pellets are made following a sulfur-modified asphalt formulation. Additionally, Thiopave® pellets must be combined with a WMA technology to lower the mixing temperature to 275°F or below to reduce hydrogen sulfide emissions. The TLA section included three asphalt layers modified with 25% TLA based on the total binder weight. In the two Thiopave® sections, the base and intermediate mixes were modified with 30% and 40% Thiopave®, respectively. The surface mixes, however, were not modified with Thiopave®.

All sections, including the conventional asphalt control, remained structurally sound with acceptable rutting, no cracking, and excellent ride quality throughout 10 million ESALs.

For more information, see NCAT Report 12-10, Sections 3.5 and 3.9.

Figure 13. Thiopave Pellets.

BINDER CHARACTERISTICS



Contact Raquel Moraes at moraes@auburn.edu for more information about the research in 4.2 and 4.3.

4.2 ASPHALT BINDER MODIFICATION

During the first research cycle, experiments were conducted to compare mixes with PG 76-22 asphalt binders modified with styrene butadiene styrene (SBS) and styrene butadiene rubber (SBR). These mixtures included dense-graded Superpave, porous friction course, and SMA. Excellent field performance was observed in all mixes regardless of the type of modifier used.

A similar experiment was sponsored by Missouri DOT and Seneca Petroleum in 2009 to compare the performance of a surface mix containing an SBS-modified binder and a ground tire rubber (GTR) modified asphalt binder. The findings demonstrated that a binder modified with GTR can perform similarly to a binder modified with SBS.

In 2021, a comprehensive experiment compared recycled GTR and post-consumer recycled plastic to SBS for asphalt binder modification. Each test section utilized an identical 12.5-mm NMAS dense-graded mixture design, incorporating 20% RAP with a design asphalt binder content of 5.6% constructed as 5.5-inch thick-lift pavements. After 10 million ESALs, field data showed no negative impact on rutting performance. While the section with GTR-modified binder developed some cracking, the sections with SBS (control) and PCR plastic-modified binders remained intact without cracking. All test sections will be retained for continued traffic in the next research cycle, allowing for a more comprehensive evaluation of their long-term field performance.

For more information, see NCAT Report 12-10 and 24-01.

4.3 EFFECT OF BINDER GRADE ON RUTTING

Superpave guidelines recommend a higher Performance Grade (PG) binder for roadways with high traffic volumes to minimize rutting. Results from the first cycle showed that permanent deformation was reduced by an average of 50% when the high-temperature grade of the binder was increased from PG 64 to PG 76. These findings also indicated the benefits of using modified asphalt binders for heavy traffic conditions.

The Alabama DOT sponsored test sections to evaluate surface mixes designed with 0.5% more asphalt binder. The results showed that increasing asphalt binder content in mixes with modified binders didn't negatively impact rutting resistance. Mixes with neat binders were more sensitive to increased asphalt content, highlighting the need for proper binder selection to ensure pavements withstand heavy traffic with minimal rutting.

For more information, see NCAT Report 02-12.

Figure 14. Example of rutting on a high traffic road.

5 STRUCTURAL DESIGN/ANALYSIS

Contact Dave Timm at timmdav@auburn.edu for more information about the research in 5.1 and 5.2.

5.1 DYNAMIC MODULUS PREDICTION

In mechanistic-empirical pavement thickness design, the dynamic modulus (E*) is a key input for asphalt layers, reflecting the effects of loading rate and temperature on mixture stiffness. Mixture stiffness influences the stress and strain the pavement experiences under truck loading, which predicts performance and determines thickness. Since direct E* measurement is complex, researchers have developed equations using easier-to-measure properties like aggregate gradation, binder viscosity, and mixture volumetrics to predict it.

A question naturally arises for any such equation regarding its accuracy. Therefore, a study was conducted to evaluate three of the most popular predictive E* models when compared to laboratory-measured E* values. These were the NCHRP 1-37A model, the NCHRP 1-40D model, and the Hirsch model.

The 1-37A and 1-40D models were part of the development of the Mechanistic-Empirical Pavement Design Guide (MEPDG) and pavement designers using the accompanying software, AASHTOWareTM PavementME Design, have the option of selecting one of the two models to make E* predictions. The Hirsch model was developed outside the MEPDG framework but has the same intent, albeit in a more simplified form than the 1-37A and 1-40D models.

The investigation featured asphalt concrete mixtures placed during the 2006 Test Track research cycle. Four different mix types were incorporated in the investigation including Superpave mixes, stone matrix asphalt mixes, rich bottom layers, and a typical mix design used by the Oklahoma DOT. A number of different binder grades were also used which, when combined with the different mix types, resulted in 10 different mixtures under evaluation.

Paving on the 8th Test Track cycle, 2021

STRUCTURAL DESIGN/ANALYSIS

5.1 *CONTINUED*

E* laboratory testing was conducted following AASHTO TP62-07 for each mix. Additionally, the requisite properties needed for the three predictive models were also directly measured following standard test protocols. These properties were entered into the three respective models to compare predicted E* versus measured E* as shown in Figure 15.

The data clearly show that the 1-40D model overpredicted the measured E*. Using this model for the tested mixtures would result in underdesigned pavement. The other two models fell more on the line of equality with the Hirsch model having less scatter. The small subset of data above and well to the left of the line of equality was attributed to a single mixture, though no explanation was found for the seemingly erroneous prediction so it remained within the analysis.

E* laboratory testing was conducted following AASHTO TP62-07 for each mix. Additionally, the requisite properties needed for the three predictive models were also directly measured following standard test protocols. These properties were entered into the three respective models to compare predicted E* versus measured E* as shown in Figure 1. The data clearly show that the 1-40D model overpredicted the measured E*. Using this model for the tested mixtures would lead to underdesigned pavement. The other two models were closer to the line of equality, with the Hirsch model showing less scatter. A small subset of data deviated significantly due to a single mixture, but no explanation was found, so it remained in the analysis.

For more information, see NCAT Report 09-08, Ch. 6

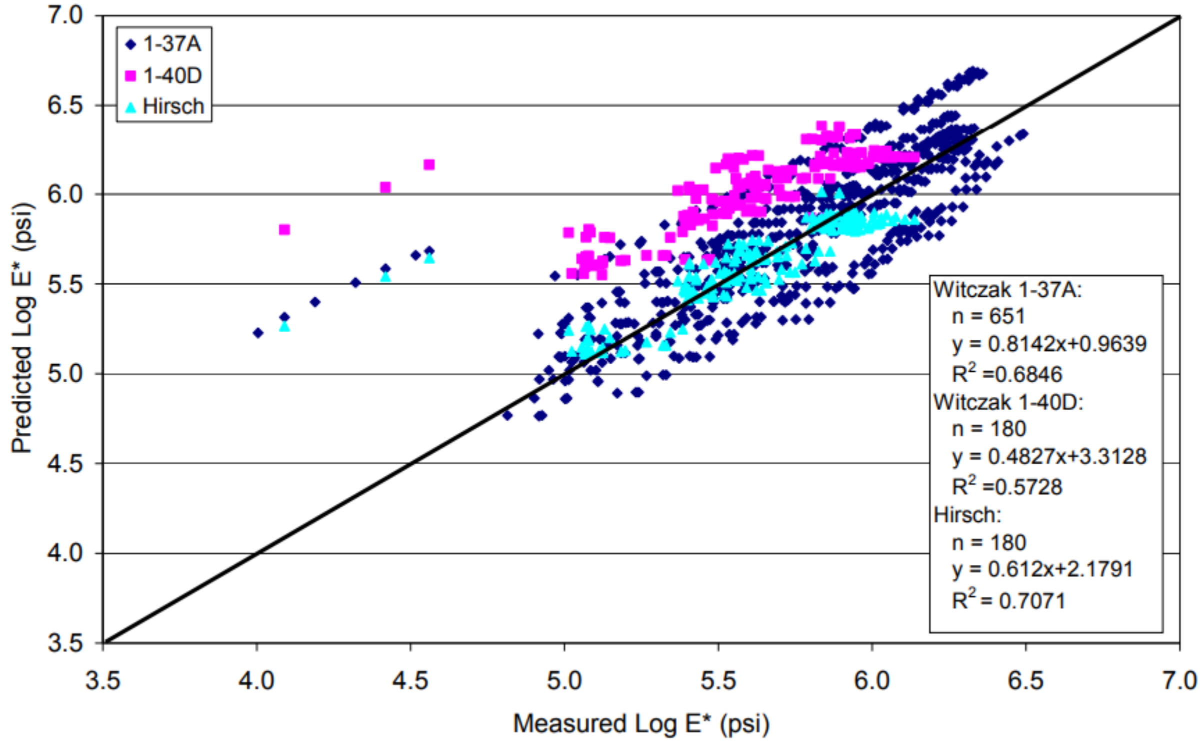


Figure 15. Predicted versus Measured E*.

5.2 ASPHALT LAYER COEFFICIENT FOR PAVEMENT DESIGN

Many highway agencies are moving toward mechanistic-empirical pavement design, but thousands of projects still rely on the empirical method from the 1958-1960 AASHO Road Test, which links pavement serviceability to traffic and structural capacity by summing the products of layer thickness and layer coefficient.

A study funded by Alabama DOT re-examined the asphalt layer coefficient using data from the second and third Test Track cycles, which included various asphalt thicknesses, mix types, bases, and subgrades. The analysis indicated that the asphalt layer coefficient should be increased from 0.44 to 0.54.

This 18% increase in the structural coefficient translates to an 18% reduction in design thickness for new pavements and overlays, as shown in Figure 16.

For more information, see NCAT Report 09-03.

A cross section taken prior to construction showing the Test Track subgrade (bottom), aggregate base (middle) and hot mix asphalt overlay (top).

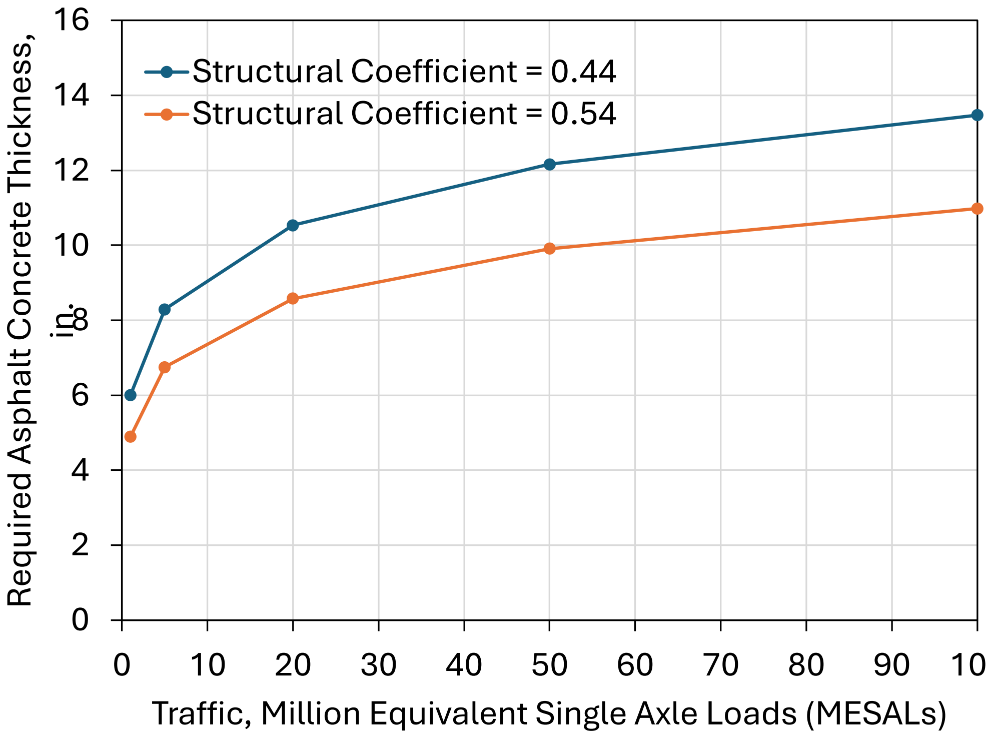


Figure 16. Impact of Structural Coefficient with Traffic Level.

STRUCTURAL PAVEMENT DESIGN AND ANALYSIS

5.3 MEASURED PERFORMANCE VERSUS MEPDG PREDICTED PERFORMANCE

Fifteen structural sections were analyzed with the AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG) using the default national calibration coefficients. The predicted pavement distresses were then compared with distresses observed in the test sections. The comparison showed the MEPDG over-predicted rutting in all sections, with errors ranging from 70% to 100%. However, rutting predictions were significantly improved after calibrating the model coefficients.

MEPDG fatigue cracking predictions with the default coefficients were also poor for most sections. In about half of the cases, the MEPDG significantly under-predicted fatigue cracking, while in some it over-predicted the amount. Attempts to adjust the fatigue model coefficients did not improve the overall correlation of predicted versus measured fatigue cracking.

For more information, see NCAT Report 12-10, Ch. 4, Section 1

5.4 MAXIMUM THICKNESS OF ASPHALT PAVEMENTS

Traditional pavement designs often result in excessively thick pavements in heavy traffic conditions. Validated through Test Track research, perpetual pavement designs focus on optimizing thickness to provide performance for over 50 years without using unnecessary materials.

The maximum thickness is achieved by keeping critical stresses and strains within safe limits, where additional material does not significantly enhance pavement performance. This thickness typically does not exceed 15.5 inches of asphalt, even in the most demanding scenarios.

Gatiganti, S., D. Timm, and N. Tran, "A Method of Maximum Thickness for Flexible Pavement Design," ALDOT Project 931-045 Final Report, Alabama Department of Transportation, 2024.

5.5 STRAIN THRESHOLD PERPETUAL PAVEMENT DESIGN

The perpetual pavement design concept has been validated through several Test Track sections. This approach involves designing each pavement layer to withstand critical stresses, ensuring that damage never occurs in the lower layers of the structure. Perpetual pavements are more cost-effective than traditional pavement designs, especially for high-traffic routes. They are also less disruptive to traffic since roadway maintenance is minimized.

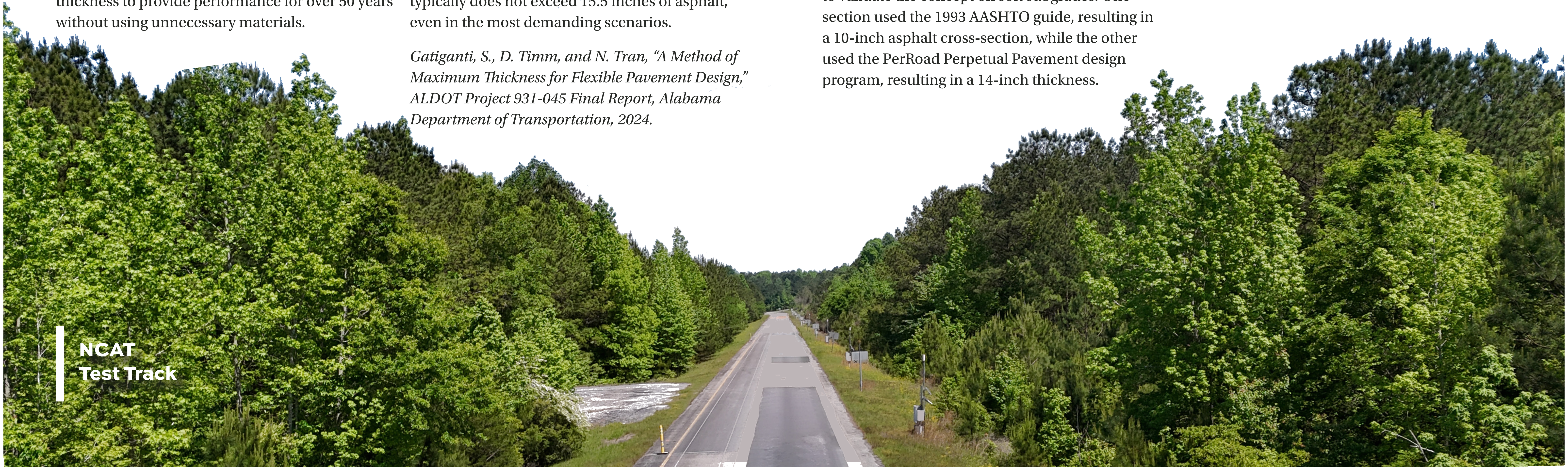
Two structural sections built for Alabama DOT in the second cycle were considered perpetual, carrying over three times their "design traffic" with only minor surface distress before being replaced for another experiment. In the third cycle, Oklahoma DOT sponsored two sections to validate the concept on soft subgrades. One section used the 1993 AASHTO guide, resulting in a 10-inch asphalt cross-section, while the other used the PerRoad Perpetual Pavement design program, resulting in a 14-inch thickness.

Contact Dave Timm at timmdav@auburn.edu for more information about the research in 5.3, 5.4, and 5.5.

The field performance of these sections confirmed the concept of limiting critical strains to eliminate bottom-up fatigue cracking. A life cycle cost analysis demonstrated that the perpetual pavement design is more cost-effective.

Three perpetual pavement sections and nine structural test sections with bottom-up fatigue cracking from the 2003, 2006, and 2009 cycles were used to develop a limiting strain distribution. This distribution, now in PerRoad Version 4.3, enables long-life perpetual pavement designs that handle heavy loads without being overly conservative.

For more information, see NCAT Report 15-05R.



6 TIRE PAVEMENT INTERACTION

6.1 HIGH FRICTION SURFACE TREATMENT (HFST) ALTERNATIVES

For safe driving, a good friction surface is crucial at critical braking and cornering locations. While the current high friction surface treatments (HFST) show the highest friction and high macro-texture characteristics for skid resistance, they require premium thermosetting polymer resin and imported calcined bauxite aggregate, making it an expensive surface treatment.

An FHWA-sponsored friction study conducted in the fifth cycle used regionally available friction aggregates to replace calcined bauxite. The results showed that polymer resin-bound surfaces with regionally available friction aggregate sources could not provide the same level of surface friction. A follow-up study in the sixth cycle evaluated asphalt-bound surfaces (instead of polymer resin) with calcined bauxite, sourced from China, as the primary friction aggregate. These surfaces included (a) two micro-surfacing treatments, one with a 50:50 aggregate blend of calcined bauxite and limestone sand and the other with 100% sandstone, and (b) a thin overlay using a 4.75 mm SMA mixture with 40% calcined bauxite, 59% granite, and 1% filler. They were placed using conventional asphalt construction equipment and methods instead of the specialized application equipment for standard HFST. Both micro-surfacing sections maintained good friction and macrotexture through 10 million ESALs. The average friction values (SN40R) were 55 for the calcined bauxite/limestone blend and 50 for the sandstone. Macro-texture (MPD) measurements were 0.70 mm and 0.90 mm for the calcined bauxite/ limestone blend and the sandstone treatments, respectively. The SMA section was placed later and received only 3.4 million ESALs of traffic. This surface also had good friction (SN40R = 55), but its macro-texture was lower (MPD = 0.35 mm) than the microsurfacing treatments. The friction measurements for the three surfaces are lower than the standard HFST surface (SN40R = 65), which has been tested for five years with over 23 million ESALs.

In 2015, the Oklahoma DOT sponsored a study to evaluate a high friction asphalt surface mixture produced with aggregates available in Oklahoma. The surface mixture selected for evaluation was an OGFC, as it had the best macro-texture. A sandstone aggregate was selected for its superior friction characteristics compared to other local aggregates tested in a prior study. After 10 million ESALs, no rutting nor noticeable cracking was observed. The highest SN40R values of 57 were measured a few months after construction, and the final SN40R values of 53 were taken in the last three months of traffic. The measured friction values were higher than the typical SN40R of 35 to 45 for other dense-graded asphalt surfaces on the Track but lower than the SN40R for the standard HFST placed in 2011, which was above 65 at the end of the same cycle. The OGFC surface had very good macro-texture with an MPD of approximately 1.2 mm over the two years of traffic.

For more information, see NCAT report 16-04, Ch. 3.10 and 18-04, Ch. 5 and 10.

6.2 LAB TESTING OF FRICTION AND TEXTURE CHANGES

NCAT used Test Track data to validate a method for determining texture and friction changes of any asphalt surface layer subjected to traffic. The procedure involved making slabs of the pavement layer in the laboratory before subjecting them to simulated trafficking in the three-wheel polishing device (TWPD). The slabs were tested for friction and texture using ASTM standards for the Dynamic Friction Tester (DFT) and the Circular Track Meter (CTM).

The Kentucky Transportation Cabinet utilized the TWPD and DFT in 2021 to design mixes to achieve specific field friction targets on the Test Track. Mix designs were tested in the lab before construction to select aggregate blends that provided specific friction levels. These mixes were placed on the Track and the friction performance was measured monthly.

Contact Nathan Moore at nathanmoore@auburn.edu for more information about the research in 6.1 and 6.2.

At the end of 10 million ESALs, the field friction level matched the expected friction from the TWPD and DFT during the design process. This study confirmed the feasibility of including friction as a future mix design target.

Gradation data and mean profile depth (MPD) from mixes in the initial four Test Track cycles (2000 – 2012) were merged to illustrate the relationship between gradation and texture. Figure 17 depicts a strong correlation between the percentage passing the #8 sieve (or the Primary Control Sieve Index) and MPD.

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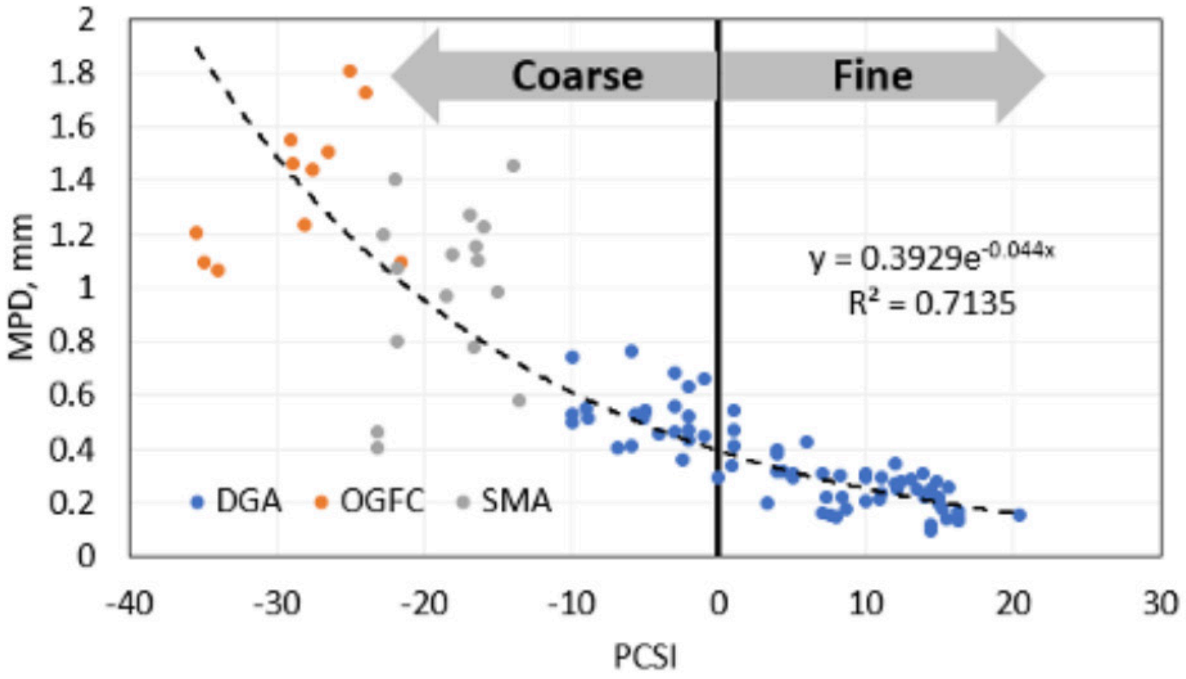


Figure 17. Relationship between Gradation-Type (PCSI) and MPD.

6.2 CONTINUED

In 2003, the South Carolina DOT evaluated a new aggregate source on the Test Track for polishing characteristics. Friction tests showed a sharp decline, deeming the aggregate unsuitable for surface mixes. This assessment was made in less than two years without endangering the public.

In 2018, the West Virginia DOT confirmed the need for a maximum limit on a local aggregate with polishing issues.

Mississippi and Tennessee DOTs conducted similar experiments, concluding that mixes with crushed gravel performed well and revised their specifications to allow more gravel. The Florida DOT tested a limestone aggregate known to polish; when sections became unsafe, they evaluated a high-friction surface treatment with epoxy binder and calcined bauxite, which provided friction for over 30 million ESALs.

For more information, see NCAT Report 24-01, Ch. 7

Figure 18. NCAT three wheel polishing device.

6.3 NOISE AND PAVEMENT SURFACE CHARACTERISTICS

Noise generated by tire-pavement interaction is significantly impacted by surface layer macrotexture and porosity, and Test Track research has shown their influence correlates with vehicle weight and tire pressure. For lighter vehicles, surface porosity is the primary factor affecting noise attenuation, while for heavier vehicles with higher tire pressures, surface macrotexture and positive texture at the tire-pavement interface play a larger role. To mitigate pavement noise, two potential approaches are using open graded friction courses and employing a small nominal maximum aggregate size mix for the surface layer.

Implementing these strategies can lead to quieter roads, improve the driving experience, and reduce noise pollution in surrounding areas. Ongoing research aims to refine these techniques, further enhancing effectiveness and sustainability.

For more information, see NCAT Report 12-10 Ch. 4.

Contact Travis Walbeck at travis.walbeck@auburn.edu for more information about the research in 6.3.

7 ADDITIONAL FINDINGS

7.1 THICK LIFT PAVING

Experimental work with thick lift paving began at the Test Track in 2018 when the South Carolina DOT funded a section to examine the constructability, structural characteristics, and performance of an 8-inch thick section paved in a single pass. Advantages of this approach include eliminating lift interfaces, reducing construction time, and simplifying construction. Potential liabilities were identified as longer cooling times that could extend reopening to traffic, smoothness, and long-term performance. Key findings included:

- The construction of a single 8-inch lift is viable. Cooling time before opening to traffic can be managed by coordinating paving time with the season and time of day.
- Achieving density exceeding 95% of the theoretical maximum was accomplished with standard rollers and roller patterns; no specialized processes or equipment were needed.
- As-built smoothness was a challenge with thick-lift paving but was improved through diamond grinding. With more experience in thick-lift paving and an additional lane for equipment, smoothness could be significantly enhanced.

The section was trafficked through the initial two years of testing, accumulating approximately 10 million ESALs. During that time, rutting increased to approximately 0.15 inches, which was considered good performance. A small amount of top-down cracking formed at the end of the test cycle but only represented 0.7% of the lane area, which was also considered good performance.

Contact Dave Timm at timmdav@auburn.edu for more information about the research in 7.1.

Pavement roughness decreased over time as traffic smoothed out the initial pavement roughness built into the section.

The section performed well enough to continue trafficking into the next cycle for another 10 million ESALs. During this time, rutting increased to approximately 0.25 inches, top-down cracking grew to 5% of the lane area without an increase in severity, and smoothness continued to improve. The technique worked so well that it was used for the subsequent Additive Group experiment.

For more information, see NCAT Report 21-03, Ch. 15.

Timm, D.H., "Thick Lift Paving at the NCAT Test Track," The Alabama Roadbuilder, Alabama Road Builders Association, Spring 2019, pp. 6 – 8.

Figure 19. Roller on NCAT Test Track.

ADDITIONAL FINDINGS

7.2 THIN LIFT OVERLAY

Thin HMA overlays (less than 1¼-inches thick) are a common, cost-effective treatment for pavement preservation; about half of U.S. states use 4.75 mm NMAS mixtures in thin overlay applications. These mixtures can be placed as thin as ½ inch.

In 2003, the Mississippi DOT sponsored a test section with a 4.75 mm surface mix containing limestone screenings, finely crushed gravel, and local sand with a polymer-modified asphalt binder. This 20-year-old section has carried more than 70 million ESALs with less than 3 mm of rutting and less than 5% cracking, proving that well-designed 4.75 mm mixes are durable for pavement preservation. In 2012, the 4.75 mm NMAS mix was redesigned by adding RAP, switching to neat asphalt binder, eliminating imported stone screenings, and using local surplus sand. After 20 million ESALs, no cracking, rutting, roughness, raveling, or friction deficiencies were noted, demonstrating cost-effective performance using local materials, RAP, and neat asphalt binder in a thin surface layer.

Contact Travis Walbeck at travis.walbeck@auburn.edu for more information about the research in 7.2.

In 2015, the Tennessee DOT evaluated a 4.75 mm mix in a 1.5-inch lift for rutting resistance. The mix, designed with 16% fine RAP and a total binder content of 6.8%, including a 0.13 RAP binder ratio and PG 64-22 neat asphalt binder, showed excellent performance with no cracking, less than 2.0 mm rutting, and good smoothness after approximately 30 million ESALs. It also maintained a stable friction value and increased macrotexture under traffic.

For more information, see NCAT Reports 18-04, Ch. 9 and 11.

7.3 ALTERNATIVE INTERLAYERS

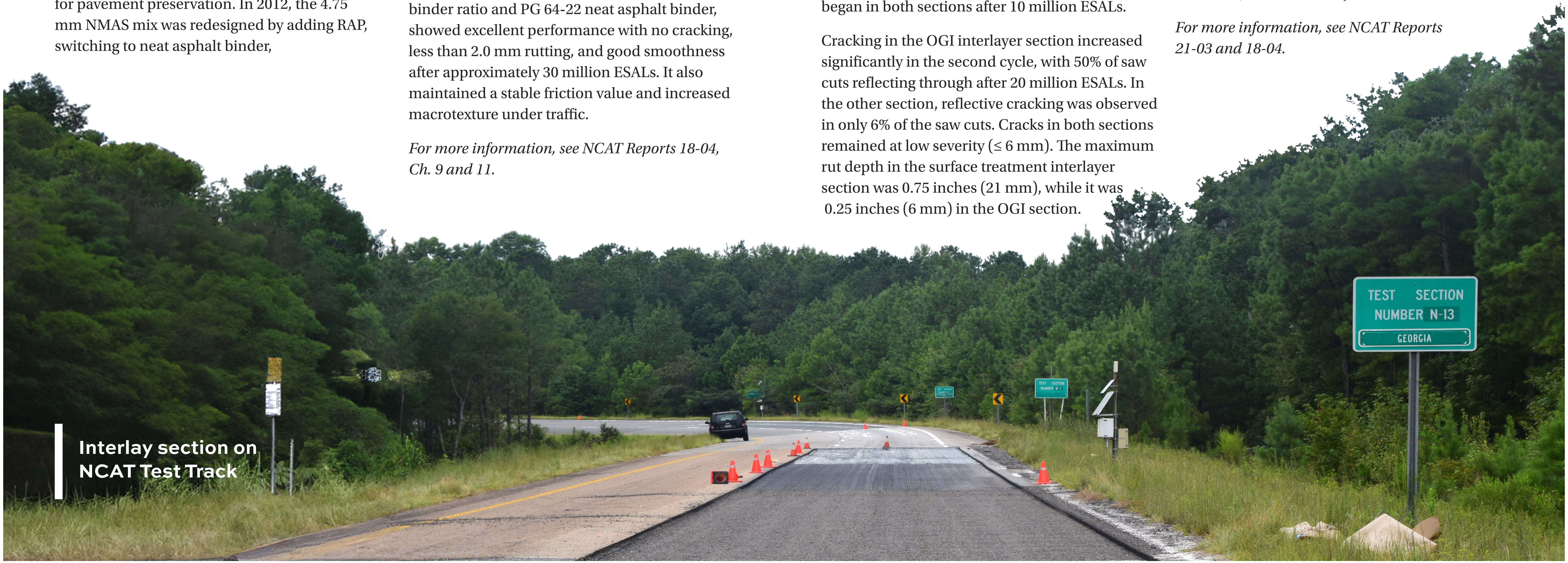
Several state agencies use cracking relief interlayers to reduce reflective cracking between existing surfaces and new overlays. In Georgia, a single chip seal treatment is commonly specified but has not been very effective. Thus, the Georgia DOT sponsored a study at the Test Track starting in 2012 to evaluate alternative interlayers. To simulate cracking, deep saw cuts in two test sections were filled with sand. One section was treated with a double chip seal with a sand seal top layer and the other with a 9.5-mm open-graded interlayer (OGI). Both were covered with a 9.5-mm NMAS dense-graded overlay. Cracking began in both sections after 10 million ESALs.

Cracking in the OGI interlayer section increased significantly in the second cycle, with 50% of saw cuts reflecting through after 20 million ESALs. In the other section, reflective cracking was observed in only 6% of the saw cuts. Cracks in both sections remained at low severity (≤ 6 mm). The maximum rut depth in the surface treatment interlayer section was 0.75 inches (21 mm), while it was 0.25 inches (6 mm) in the OGI section.

Contact Thomas Harman at tom.harman@auburn.edu for more information about the research in 7.3.

In 2018, Georgia DOT expanded its investigation of cracking relief interlayers by placing six different approaches in two sections. These included two geotextiles (GlasGrid® and PETROMAT®), a virgin chip seal, a RAP chip seal, an asphalt rubber gap-graded (ARGG) mix, and an OGI. All interlayers were topped with a 9.5-mm NMAS dense-graded mix. After 20 million ESALs, one section exhibited minor rutting (RAP chip seal with 0.46 inches), and only two had minor reflective cracking (ARGG with 2.4%, OGI with 0.2%).

For more information, see NCAT Reports 21-03 and 18-04.



Interlay section on NCAT Test Track

ADDITIONAL FINDINGS

7.4 ENGINEERED RAP BASE

Cold central plant recycling (CCPR)—a highly sustainable method of combining RAP with foamed or emulsified asphalt and additives in a central recycling plant without applying heat—has been used for rehabilitating roadways ranging from low-volume roads to heavily trafficked interstates. Multiple sections of CCPR are on the Test Track, including one from the 2012 test cycle that has experienced over 40 million ESALs. This section, sponsored by the Virginia DOT, consists of four inches of HMA over five inches of CCPR with a 6-inch aggregate base. It showed no signs of deterioration until 29.7 million ESALs, so it was left in place for another 10 million and will be removed in 2024 after a deep forensic investigation and mechanistic characterization.

Contact Ben Bowers at bfbowers@auburn.edu for more information about the research in 7.4.

A section from the eighth cycle consists of a 2-inch SMA overlay above 4.5 inches of re-recycled CCPR, meaning an existing CCPR material was recycled again. Additionally, the use of CCPR with typical stabilizing agents and rejuvenators was investigated on five sections on the off-ramp of the Test Track, with four inches of CCPR and a 1-inch overlay. In all cases, CCPR performed well under heavy traffic as a high-quality, engineered RAP base.

For more information, see NCAT Reports 21-03, 18-04, and 16-04.

CCPR Production

11

MILLION MILES

NCAT's Test Track began its mileage in September 2000. It reached 11,000,000 miles on January 22, 2024.

1.7 miles of track

46 sponsored sections

5 truck fleet

RESEARCH SPONSORS

The NCAT Test Track is funded and managed as a cooperative project. Highway agencies and industry sponsors can explore specific research needs that can be evaluated in one or two test sections, and broader research needs of the asphalt pavement community can be met through experiments involving multiple test sections.

Since the results of these experiments are typically evident in the performance of the sections, the findings are generally easy to interpret. This gives highway agency sponsors confidence to make decisions regarding their specifications for materials, mixes, and construction practices, as well as pavement design methods that can improve the performance of their roadways.

Industry sponsors use the Test Track to publicly and convincingly demonstrate their product or technology to the pavement engineering community.

AGENCY

- Alabama Department of Environmental Management
- Alabama DOT
- Colorado DOT
- Federal Highway Administration
- Florida DOT
- Georgia DOT
- Indiana DOT
- Kentucky Transportation Cabinet
- Maryland DOT
- Michigan DOT
- Minnesota DOT
- Mississippi DOT
- Missouri DOT
- New York State DOT
- North Carolina DOT
- Oklahoma DOT
- South Carolina DOT
- Tennessee DOT
- Texas DOT
- Virginia DOT
- West Virginia DOH

INDUSTRY

- BASF
- Cargill
- Collaborative Aggregates
- CRH
- FP$_2$
- Kraton Polymers
- Modified Asphalt Solutions
- Oldcastle Materials
- Polycon Manufacturing
- Seneca Petroleum Company
- Shell Sulfur Solutions
- SoyLei Innovations
- Trinidad Lake Asphalt
- US Polyco

NOTES

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NCAT's mission is to provide innovative, relevant and implementable research, technology development, and education that advances safe, durable and sustainable asphalt pavements.

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