



Pushing the Limits of Pavement

Full-scale experiments across the country are working between a rock and a hard place to build longer lasting roads.

*by Nelson Gibson
and Alicia Sindlinger*

With more than 2.6 million miles of paved roadway in the United States, pavement is one of the most essential elements in the surface transportation system. However, the public may not realize that pavements are engineered structures constructed with deliberate choices in layer thicknesses and materials. At the same time, pavement materials are natural resources with an inherent variability. Road owners must bal-

(Above) Here, FHWA is constructing new pavement test sections at the Turner-Fairbank Highway Research Center in McLean, VA. The Accelerated Loading Facility (on the left) can apply full-scale traffic loads to the pavement at a faster pace than real-world tests in public rights-of-way.

ance that natural variability with the desired engineering properties and economic considerations during production and construction all the way through to maintenance and preservation. Pavement tests are one tool transportation agencies rely on to make informed decisions about investments and new pavement technologies.

Pavement testing helps agencies understand how combinations of raw materials and techniques for mixing them will affect performance under varying conditions, such as traffic loads and environmental factors. The goal is to uncover potential benefits—for example, lower cost but equivalent performance—from introducing alternative materials, designs, or paving processes into highway infrastructure.

Pavement researchers use several levels of testing from small-scale, short-term laboratory and computer modeling experiments to long-term, real-world tests. In between is full-scale accelerated pavement testing, which represents a vital link between laboratory evaluations and the real-life performance of a pavement installed on an inservice road.

“The most accurate information on real-world pavement performance is obtained by building test sections on the public right-of-way and studying performance under real traffic and environmental conditions for many years, as we do in our Long-Term Pavement Performance program,” says Cheryl Allen Richter, assistant director for Pavements Research and Development with the Federal Highway Administration

(FHWA). “With new pavement technologies, we can’t always afford to wait that long for answers. One solution is to use accelerated loading technologies to approximate many years’ worth of traffic loads within a condensed time period.”

Full-scale accelerated pavement tests assess the performance of materials and techniques that simulate the distresses observed throughout an entire life cycle but in a significantly shorter period, typically a few months to several years. The Transportation Research Board’s (TRB) National Cooperative Highway Research Program (NCHRP) *Synthesis 433: Significant Findings from Full-Scale Accelerated Pavement Testing* defines this type of analysis as the “application of full-scale wheel loads to layered, structural pavement systems to determine pavement response and performance under controlled, accelerated accumulation of damage loading in a compressed time period. This is done while environmental effects on the pavement are typically controlled and measured.” Testing facilities, typically located at Federal, State, and university research centers, use a variety of devices and instrumentation to apply full-scale wheel loads and measure the pavement response.

Benefits include cost savings and increased safety compared to working on roadways open to traffic. Also, results tend to carry a higher level of significance and confidence compared to smaller scale laboratory tests. Full-scale testing circumvents having to wait for results to accumulate at a slower rate under actual traffic and avoids the risks of potential costs and dangers due to failures under actual traffic loading. Further, accelerated testing enables researchers to control for major experimental, traffic, and environmental variables and helps them apply the results to other conditions.

FHWA’s Office of Infrastructure Research and Development (R&D) conducts full-scale accelerated pavement testing at its Turner-Fairbank Highway Research Center (TFHRC) in McLean, VA. Currently, 13 other facilities across the country also conduct similar types of experiments. The geographic spread of these facilities accounts for local variations in climate, traffic, and the natural

materials that go into pavements, such as locally available aggregates. Here is a look at the history of pavement testing and the latest research underway at some of these facilities.

Research in the United States

The study of pavement performance under controlled conditions has a long history in the United States. In 1954 the American Association of State Highway Officials (AASHO), predecessor to the American Association of State Highway and Transportation Officials (AASHTO), launched a seminal road test that ran until 1960. The AASHO Road Test studied the performance of both flexible asphalt pavements and rigid concrete pavements and bridges on six different test tracks with 126 vehicles in the test fleet. The road test laid the foundation for most of today’s pavement management models and engineering design tools.

Historically, much of the country’s nationally coordinated pavement research has focused on long-term pavement performance. FHWA’s Long-Term Pavement Performance (LTPP) program, for example, collects data on more than 2,500 pavement sections under real traffic loadings and in different climatic and subgrade conditions. In fact, the NCHRP used nationwide data from the LTPP program, as well as data from Minnesota’s MnROAD pavement test facility, to calibrate portions of the *Mechanistic-Empirical Pavement Design Guide* (now AASHTOWare® Pavement ME Design).

FHWA’s Aramis López, team leader for the LTPP program, says accelerated pavement testing complements these LTPP field performance studies. “Each type of study stands on its own,” he says. “The results of each reinforce the findings of the other to build a more holistic picture of the performance of pavement assets.”

Today, full-scale accelerated testing programs are expanding in the United States and internationally as pavement owners feel the pressure to do more with less. The increased

interest has led to three broad cooperative activities: in the United States, the creation of the TRB technical committee on Full-Scale and Accelerated Pavement Testing (AFD40) and the Transportation Pooled Fund Consortium of Accelerated Pavement Testing (TPF-5(127)), and in Europe, the establishment of the COST (Cooperation in Science and Technology) Pavement Research with Accelerated Loading Testing Facilities program.

These groups bring researchers together to further the use, development, and exchange of information on accelerated pavement testing and to generate findings that can be applied to the broader field of pavement engineering. For example, the TRB committee sponsors an international conference every 4 years that brings the research community together to share and discuss their experiments.

Accelerated Pavement Testing at FHWA

In 1986, FHWA established the Pavement Test Facility at TFHRC to provide researchers with the capability to simulate an entire life cycle of accumulated damage on full-scale pavement structures in just a few months.

The test facility is a 0.5-acre (0.2-hectare) outdoor laboratory featuring two Accelerated Loading Facility (ALF) units. The ALF units are linear machines with a trolley that simulates one half of a single truck axle that can be fitted with various tire configurations (single or dual). Researchers can adjust the wheel load levels from 10,000 pounds (4.5



These FHWA researchers are documenting the temperature of a pavement mixture as it is being placed.

Web Sites for Selected Accelerated Pavement Testing Facilities

Facility	URL
FHWA's Pavement Test Facility	www.fhwa.dot.gov/research/tfhrc/labs/pavement
California Department of Transportation/University of California Pavement Research Center	www.ucprc.ucdavis.edu/AcceleratedPavementPage.aspx
Indiana Department of Transportation/Purdue University Accelerated Pavement Testing Facility	http://rebar.ecn.purdue.edu/APT/
Florida Department of Transportation Accelerated Pavement Testing and Research	www.dot.state.fl.us/statematerialsoffice/pavement/research/apt
University of Texas at Arlington Accelerated Pavement Research Facility	Not yet available
University of Illinois at Urbana-Champaign Accelerated Testing Facility	http://ict.illinois.edu/transportation_engineering/facilities/accelerated_testing_facility.html
Kansas State University/Kansas Department of Transportation's Civil Infrastructure Systems Laboratory	www.ce.ksu.edu/node/207
Minnesota Department of Transportation's MnROAD	www.mndot.gov/mnroad
National Center for Asphalt Technology Pavement Test Track	www.ncat.us/facilities/test-track.html
Federal Aviation Administration's National Airport Pavement Test Facility	www.airporttech.tc.faa.gov/naptf

metric tons) to 23,000 pounds (10.4 metric tons) simulating legal to heavily overloaded truck traffic. The loaded wheel travels over pavement test sections in one direction at 11 miles per hour (18 kilometers per hour) and simulates the random left-to-right wheel "wander" that naturally occurs in vehicles' wheelpaths. The machines can make approximately 50,000 passes per week.

Each pavement test segment is approximately 46 feet (14 meters) long and 13 feet (4 meters) wide, allowing for the study of rutting (permanent deformations) and load-associated cracking. The testing space can accommodate 12 separate full-scale pavement test lanes, and each lane provides 4 test sites for a total of 48 potential study segments. Radiant heaters control high pavement temperatures year-round for rutting studies and also provide intermediate temperature control for fatigue cracking during cooler weather. Other onsite equipment includes laser surface profilers; digital crack map readers; falling weight deflectometers; surface wave spectral analyzers; and data acquisition systems for embedded electronic gauges for measurements of strain, deflection, and stress response.

The Pavement Test Facility has a history of accomplishments. The first few studies after its establishment identified that axle load equi-

valency factors for heavy loads and thinner pavement structures were higher than conventionally accepted. The studies also identified the influence of tire type and inflation pressure on performance, but found axle load levels have a far greater impact.

Shortly thereafter, FHWA evaluated a single tire alternative to the standard configuration of dual truck tires known as super-singles for potential effects on pavement damage. The study quantified that trucks outfitted with super-single tires could cause significantly more fatigue cracking and nominally more rutting. An ongoing pooled fund study at the accelerated pavement testing facility in Illinois is currently evaluating the second generation of these single tires known as wide-base super-singles.

In 1993, the facility acquired a second ALF unit for a large study to validate the performance-graded specifications for Superpave (SUPERior PERforming Asphalt PAVements) asphalt binder developed under the Strategic Highway Research Program. FHWA researchers conducted experiments on rutting and fatigue cracking with different asphalt binders and found that the rutting specification for performance-graded binder indicated the correct performance trends for unmodified asphalt. Results showed that the binder

performance-graded fatigue specification was most applicable to the thinner asphalt pavements.

The distressed asphalt pavements from this experiment then were rehabilitated with thin overlays of portland cement concrete, also known as ultrathin whitetopping. Researchers studied eight sections with various combinations of thickness, joint spacing, and plain or fiber-reinforced concrete mixtures. Results from measurement of slab cracking under the ALF loading were shared with researchers with FHWA's Concrete Pavement Technology Program and with the Innovative Pavement Research Foundation for the development of design software for whitetopping overlay applications.

More recently, the facility revisited asphalt binder performance-graded specifications for Superpave to address discrepancies regarding the unsatisfactory ability to capture the performance contributions of polymer-modified asphalt binders. The results identified several candidate tests for rutting and fatigue cracking specifications for asphalt binders that adequately capture the performance of both unmodified and polymer-modified asphalts. One of the tests is now an AASHTO provisional test method (TP 70: Standard Method of Test for Multiple Stress Creep Recovery

Test of Asphalt Binder Using a Dynamic Shear Rheometer).

The FHWA Pavement Test Facility also contributes data, materials, and resources to support a number of other projects including key, national NCHRP projects. For example, laboratory data and samples of pavement materials provided benchmarks for performance test methods and equipment such as the Asphalt Mixture Performance Tester, a technician-friendly tool for the pavement community that provides engineering properties of asphalt pavement materials for AASHTOWare® Pavement ME Design.

Today, FHWA's accelerated pavement testing program is focused on sustainability. In October 2013, the facility completed a reconstruction of the test sections to study the combination of two sustainable technologies: (1) increased use of recycled materials in highways and (2) reduced-temperature warm-mix asphalt. The full-scale test sections were constructed with varying degrees of recycled content using alternative production technologies that are more environmentally friendly than previous techniques. FHWA will test the sections to failure through 2015 to establish realistic boundaries for mixtures with high amounts of recycled content that employ warm-mix asphalt production technologies. The research will identify optimal pairings of the two technologies, while ensuring that they have limited or no impact on performance compared to conventional pavement materials.

In addition to FHWA's efforts, full-scale testing facilities across the country are making significant contributions to enhance pavement performance. Among them are facilities in California, Indiana, Florida, Texas, Illinois, Kansas, Minnesota, Alabama, and New Jersey.

California Pavement Research Center

In 1994, the California Department of Transportation (Caltrans)/University of California acquired

two heavy vehicle simulators and ushered its understanding of accelerated pavement testing into the modern era. Since 1995, the University of California Pavement Research Center has operated the two machines in 21 different project investigations, testing more than 150 instrumented sections, with 80 million load repetitions applied—equal to more than 4.2 billion equivalent single-axle loads.

These project investigations have looked at a variety of factors including evaluation of long-life rehabilitation strategies for rigid pavements, performance of drained and undrained flexible pavements, and rehabilitation of precast concrete panels for long-life highways. Other studies focused on dowel bar retrofits for rigid pavements, the use of warm-mix asphalt technologies in conventional and rubberized asphalt, and rutting and clogging performance of new open-graded asphalt concrete mixes with smaller maximum sizes to improve durability and noise performance. Another study reviewed a new joint design for the deck of the San Francisco-Oakland Bay Bridge. Still other investigations have verified rehabilitation designs for long-life flexible pavements for the I-710 freeway and overlay thicknesses for Caltrans' rubberized asphalt overlay designs.

Results from California's experiments are analyzed in combination with laboratory and field testing results to answer specific questions for Caltrans and other clients.

All results are saved into relational databases. To answer complex questions, such as calibration of mechanistic-empirical design procedures, researchers bring together the results of multiple projects to provide a much larger data set.

"Over the years, the [University of California] Pavement Research Center has made significant contributions to the field of accelerated pavement testing," says Coco Briseno, chief of the Caltrans Division of Research, Innovation and System Information. "This collaborative partnership has allowed us to stay on top of new technologies, which improve our choices in pavement design while incorporating sustainability and environmental stewardship into our end product."

Indiana Accelerated Pavement Testing Facility

The Indiana Department of Transportation (INDOT), in association with Purdue University, operates an accelerated pavement testing facility in West Lafayette, IN. The facility is housed in a 2,000-square-foot (186-square-meter), environmentally controlled building outfitted with a test pit, loading mechanism, and control and monitoring equipment. The indoor facility allows for more precise control of temperature and other factors.

The equipment can apply loads with a dual wheel or a super-single half-axle assembly traveling over the test pavement at 5 miles (8 kilometers) per hour and may be

This heavy vehicle simulator at California's Pavement Research Center is testing a section of warm-mix asphalt.



University of California Pavement Research Center



Shown here is INDOT's loading mechanism and the test pit that will be constructed with asphalt or concrete pavement.

we've continually improved the hot-mix asphalt pavement specification...since the adoption of Superpave mix designs to minimize pavement rutting and thermal cracking, as well as pavement fatigue cracks."

INDOT's Barry Partridge, director of research and development, adds, "Accelerated findings in a low-risk, controlled setting [are] achievable [at] the Indiana

Accelerated Pavement Testing Facility. This allows for early adoption and implementation of viable research results and new products."

Florida Facility

In 2000, the need for faster and more practical evaluation methods under closely simulated inservice conditions prompted the Florida Department of Transportation (FDOT) to initiate an accelerated pavement testing program con-

ducted through partnerships with the local university system, industry, and FHWA. Located in Gainesville, FL, the testing facility originally consisted of eight linear test tracks, each 150 feet (46 meters) long and 12 feet (4 meters) wide, and two test pits, measuring 50 feet (15 meters) long and 12 feet (4 meters) or 18 feet (5 meters) wide. Both test pits have the capability to control the water table within the supporting base and subgrade layers. In 2011, FDOT extended seven of the test tracks by 300 feet (90 meters) each to better represent field paving practices and to accommodate additional test sections. A heavy vehicle simulator applies accelerated wheel loading to the test tracks.

The FDOT program selects projects on an annual basis and has investigated flexible, rigid, and composite pavements over the last decade. Project focuses have included gradation of hot-mix asphalt mixtures, the use of asphalt binders modified with polymer and ground tire rubber, damage due to various tire types, the effect of stress-absorbing membrane interlayers, aging of hot-mix asphalt, and early strength gain of concrete. In addition to research on pavement systems, FDOT has used its heavy vehicle simulator to investigate the performance of raised pavement markers and a fiber-reinforced polymer bridge deck.

"Most important is the impact the accelerated testing program has had on pavement construction

operated unidirectionally or bidirectionally. A loading mechanism applies and maintains a constant force up to 20,000 pounds (9 metric tons) on the wheel assembly. With modifications, researchers can increase this half-axle loading to 40,000 pounds (18 metric tons), applied statically or as a programmed dynamic load function.

Since it was established 12 years ago, INDOT's testing program has investigated flexible and rigid pavements. Experiments have included gradation of hot-mix asphalt mixtures, validation of Superpave mix designs, damage due to various types of tires, structural evaluations, hot-mix asphalt mixes with low air voids, ultrathin whitetopping, and early strength gain requirements of concrete.

"The results of these studies benefit INDOT in terms of new and better policies, procedures, construction practices, and specifications to achieve more durable, longer lasting pavement," says Mark Miller, chief engineer at INDOT. "For example,

This heavy vehicle simulator applies accelerated wheel loading to FDOT's test tracks.



This pavement testing machine is parked on top of the first pair of experimental pavement sections constructed at the University of Texas at Arlington.



University of Texas at Arlington

and design practices,” says Bouzid Choubane, State pavement material systems engineer with FDOT. The research program led to the revision of FDOT’s *Flexible Pavement Design Manual* and construction specifications and has provided critical information to policymakers. Early examples of implemented accelerated pavement testing research include the adoption of polymer-modified asphalt binders and the development of criteria for their use, as well as allowing use of fine-graded Superpave asphalt mixtures. In addition, FDOT has allowed the use of wide-base tires and is currently funding the study of more effective treatments for mitigating reflection cracking based on research that showed FDOT’s current strategy is ineffective. FDOT estimates that the implementation and optimization of polymer-modified asphalt binders, and the use of fine-graded Superpave asphalt mixtures saves taxpayers more than \$4 million each year.

University of Texas at Arlington

The University of Texas at Arlington established its accelerated pavement testing program in 2012 at Fort Worth, TX. The main components of

the facility are the experimental test area and a pavement testing machine.

The experimental test area is a 150-foot by 150-foot (46-meter by 46-meter) elevated area with 3 feet (0.9 meter) of imported subgrade soil placed on top of the existing silty clay soil. A total of 30 full-scale experimental pavement sections can be constructed on top of the subgrade soil with conventional pavement construction equipment. The pavement testing machine makes approximately 600 passes per hour in bidirectional loading mode and around 300 passes per hour in unidirectional loading mode. The maximum single-axle load it can apply is approximately 40,000 pounds (18 metric tons).

The program’s first research project, sponsored by the Texas Department of Transportation (TxDOT), is being conducted in collaboration with the Texas A&M Transportation Institute. The proj-

ect aims to optimize the design of asphalt mixes that contain recycled asphalt pavement and recycled asphalt shingles. Researchers built 12 experimental pavement sections to evaluate the performance of 4 mixes for rutting, fatigue cracking, and reflection cracking. The mixes contain the maximum amount of recycled materials currently allowed by TxDOT specifications.

University of Illinois at Urbana-Champaign

The Illinois Center for Transportation’s Advanced Transportation Research and Engineering Laboratory is home to most of the pavement research ongoing at the University of Illinois at Urbana-Champaign. The laboratory is a state-of-the-art facility that has 67,000 square feet (6,225 square meters) of research space, a distance learning and continuing education classroom, offices, and an outdoor pavement testing facility.

The laboratory’s Accelerated Transportation Loading Assembly (ATLAS) is a full-scale testing apparatus that can examine pavement sections up to 85 feet (26 meters) each. ATLAS is capable of simulating aircraft and truck traffic load distributions, testing all types of pavement systems, and applying load levels exceeding highway and airfield loading limits. The system can accommodate a single tire, dual tires, aircraft tires, or a single-axle



Illinois Center for Transportation

This wide-base tire assembly is involved in testing unbound pavement layers in a full-scale performance evaluation at the Illinois Center for Transportation.

rail bogey. A recently installed climatic control system enables ATLAS to maintain constant pavement temperatures during testing year-round.

"ATLAS has been an effective testing device that allows us to validate developed theories and laboratory tests using full-scale constructed pavement sections in the lab backyard," says Imad L. Al-Qadi, director of the Illinois Center for Transportation. "The ability to measure pavement responses to various controlled loadings provides better understanding of pavement layer and material behavior and performance."

For the past 10 years, researchers have used ATLAS to test numerous full-scale pavement sections. These tests include projects to assess the performance of continuously reinforced concrete, full-depth perpetual pavements, geosynthetically reinforced pavements, whitetopping concrete overlays, composite pavements, interlayer and tack coat effectiveness, and low-volume roads.

For example, in one experiment, researchers constructed pavement test sections with two different moisture-sensitive asphalt mixtures using six additives to control moisture damage. The project outcomes provided crucial feedback to the Illinois Department of Transportation about the efficiency and importance of using additives or modifiers to control moisture damage. In another study, researchers constructed nine highly instrumented, low-volume road pavement sections with various layer thicknesses and reinforced by various types of geosynthetic interlayers. The study resulted in the quantification of geosynthetic benefits in pavement performance and provided recommendations on the optimum location for its use.

Kansas State University/ Kansas Department of Transportation

The Department of Civil Engineering at Kansas State University and the Kansas Department of Transportation (KDOT) jointly developed the Civil Infrastructure Systems Laboratory, which opened in 1996. The laboratory houses an indoor accelerated pavement testing facility with approximately 5,000 square feet (465 square meters) of test area. A test frame with a 42-foot (13-meter) span has

a single- or tandem-axle assembly rolling at a speed of 7 miles per hour (11 kilometers per hour) over pavement specimens up to 20 feet (6 meters) long. The frame has an enclosure that enables researchers to regulate the air and surface temperature during the test.

The testing facility has the capability to test hot-mix asphalt pavements for rutting or fatigue cracking, thermal effects, reinforced base effectiveness, drainable base effectiveness, freeze/thaw cycling, and pumping action in portland cement concrete pavements.

To date, the laboratory has conducted 18 experiments. Recent studies include testing of unpaved and paved roads with geocell and geosynthetic reinforcement and verification of mechanistic-empirical design models for flexible pavements. The latter project, conducted by the Midwest States Accelerated Testing Program under a pooled fund, aimed to verify the models in use in AASHTOWare® Pavement ME Design for the design of new flexible pavements. For this test, researchers constructed and evaluated 12 experimental pavement structures at the lab between 2006 and 2009.

"The accelerated testing program at the Civil Infrastructure Systems Laboratory...has been very valuable to the Kansas Department of Transportation [KDOT] in evaluating the impact of different pavement structures and mix characteristics on pavement performance," says Greg Schieber, assistant bureau chief of materials with KDOT. "The research has directly influenced changes to KDOT pavement design policy that

have resulted in improved pavement performance on Kansas roadways."

Minnesota MnROAD Test Facility

The Minnesota Department of Transportation's MnROAD Test Facility is a full-scale accelerated pavement test track owned and operated by the Minnesota Department of Transportation. Located near Albertville, MN, MnROAD was constructed between 1991 and 1993. The track has two road segments with nearly fifty 500-foot (152-meter) test sections located next to I-94. One segment is a 3.5-mile (5.6-kilometer) mainline interstate roadway carrying live traffic averaging 29,000 vehicles a day. The second is a 2.5-mile (4-kilometer) closed-loop, low-volume roadway carrying a controlled, fully loaded (80,000 pounds, 36 metric tons) five-axle semitrailer to simulate conditions on rural roads.

The first phase of MnROAD research ended in 2006 and focused on the structural design of concrete, bituminous, and gravel pavement designs. Outcomes showed that past pavement designs were too

Brandon Bortz, a graduate research assistant at Kansas State University, is operating a light falling weight deflectometer with a PDA controller.



Civil Infrastructure Systems Laboratory at Kansas State University



From this aerial view, the two segments of MnROAD's test track are visible. The interstate segment is on the right and the closed loop is on the left.

National Center for Asphalt Technology

The Pavement Test Track operated by the National Center for Asphalt Technology at Auburn University is a full-scale, accelerated performance testing facility for flexible pavements. Located in eastern Alabama, the facility has forty-six 200-foot (61-meter) test sections installed around a 1.7-mile (2.7-kilometer) oval track. Researchers subject the test sections to accelerated damage via a fleet of tractors pulling heavy triple trailers. In addition, a local county road that provides one-way access to a quarry and an asphalt plant now serves as a testbed for research on pavement preservation.

The primary objectives of research on the Pavement Test Track are to study how thick pavements need to be built, to identify methods and materials that minimize construction costs and improve life-cycle performance for each layer in the structure, and to quantify the benefits of pavement preservation.

Some of the track's past experiments involved increasing use of recycled and reclaimed materials in asphalt pavements, implementing warm-mix asphalt, and improving

conservative and environmental factors were not fully taken into account when selecting materials. The benefits included a reduction in thermal cracking around the State, scientific-based seasonal load policy, reductions in required surface thickness, and a reinforced importance of sealing pavement cracks and shoulder joints.

MnROAD is now in its second phase of research, which started in 2007. Some recent studies have included investigation of warm-mix asphalt, quiet diamond grinding, whitetopping overlay design, pervious pavements, stabilized full-depth reclamation, low-temperature cracking in asphalt pavements, and preventative measures for hot-mix asphalt pavements. One study tested the effects of husbandry on pavement performance. Researchers compared the stress and strain behavior of pavements under loading from large and heavy farm equipment compared to five-axle semitrailer loads on two test sections of MnROAD. Following the study, researchers recommended cost-effective solutions to minimize

damage to pavements by working with farmers to haul materials in the mornings when the temperature is cooler and the asphalt roadway is less susceptible to loads, to provide seasonal one-way roadways to keep the equipment off the weaker shoulders, and to work with equipment manufacturers related to the size and weights of future equipment.

MnROAD's third phase of research, slated for construction in 2016, will focus on maintenance and rehabilitation. To get involved with MnROAD and planning for future projects, visit www.mndot.gov/mnroad.

The National Center for Asphalt Technology tests pavement sections on this 1.7-mile (2.7-kilometer) oval track in Alabama.



At this indoor facility in Atlantic City, NJ, researchers with the FAA conduct studies on the performance of pavement test sections designed for use on airport runways.

the constructability and durability of Superpave mixes. Other studies focused on quantifying the benefits of modified binders, recalibrating the layer coefficient for modern asphalt pavements to reduce empirical overdesigns, determining critical values for quality control testing, and validating laboratory methods to prevent top-down cracking. Current research includes testing pavement sections that were placed in summer 2012, with a focus on sustainable materials and methods, enhanced pavement interlayers, and pavement preservation.

FAA Facility in New Jersey

In addition to the aforementioned facilities studying highway pavements, another—the indoor Federal Aviation Administration (FAA) National Airport Pavement Test Facility—is focused on performance of airport pavements. Located in New Jersey, the facility opened in 1999 and is used to generate data on pavement response and performance for development and verification of design criteria for airport pavements.

The test facility consists of a 900-foot (274-meter)-long by 60-foot (18-meter)-wide test pavement area, with embedded pavement and environmental instrumentation and both static and dynamic data acquisition systems. The test vehicle is capable of loading the pavement sections with a maximum of 12 aircraft tires at wheel loads up to 75,000 pounds (34 metric tons) per tire.

Some of the facility's major accomplishments include updated failure models for FAA's design procedures for flexible, rigid, and overlay pavements and modifications to existing alpha factors (pavement thickness reduction factors) for landing gear configurations. Other research led to adoption of new tire pressure limits that will allow newer aircraft with higher tire pressures to operate at airports around the world and development of a



FAA

design procedure for the thickness of hot-mix asphalt overlays over rubblized concrete pavements. In 2013, the National Airport Pavement Test Facility received the Robert Horonjeff Award from the American Society of Civil Engineers in recognition of its advancements to the field of air transportation engineering.

Future research will include full-scale testing of long-lasting hot-mix asphalt pavements, hot-mix asphalt overlays on concrete pavements to study reflective cracking, allowable aircraft overload criteria for flexible pavements, and sustainable technologies such as warm-mix asphalt and recycled asphalt products using FAA's recently acquired heavy vehicle simulator.

Last Thoughts

"Use of accelerated testing continues to grow and become an integral part of pavement research operations, with benefits that include improved structural and material design methods, performance modeling, and evaluation of new materials and structures," says Ben Worel, MnROAD operations engineer. "Through well-planned studies over the last two decades, full-scale accelerated pavement testing at FHWA and elsewhere around the country has provided important information to the pavement engineering community."

NCHRP's *Synthesis 433* report summarized and documented significant findings from the various experimental activities associated

with these programs between 2000 and 2011.

"The results of these studies have directly contributed to improvements in the sustainability, durability, and cost-effectiveness of pavements," Worel says.

Moving forward, according to the NCHRP report, hot-mix asphalt will continue to be a major focus of accelerated testing programs. At FHWA in particular, research also is trending toward evaluation of environmentally sensitive materials, such as warm-mix asphalt and recycled asphalt materials, and application of hot-mix asphalt overlays and ultrathin whitetopping to extend pavement life.

Nelson Gibson, Ph.D., P.E., is a research civil engineer with FHWA's Office of Infrastructure R&D and manages the FHWA asphalt materials laboratories and the Pavement Test Facility. He is a member of the Association of Asphalt Paving Technologists, the American Society of Civil Engineers, and the TRB technical committee on Full-Scale and Accelerated Pavement Testing.

Alicia Sindlinger is the associate editor for PUBLIC ROADS.

For more information, contact Nelson Gibson at 202-493-3073 or nelson.gibson@dot.gov. The authors would like to thank the featured facilities for their contributions to this article.