TEXAS TRANSPORTATION

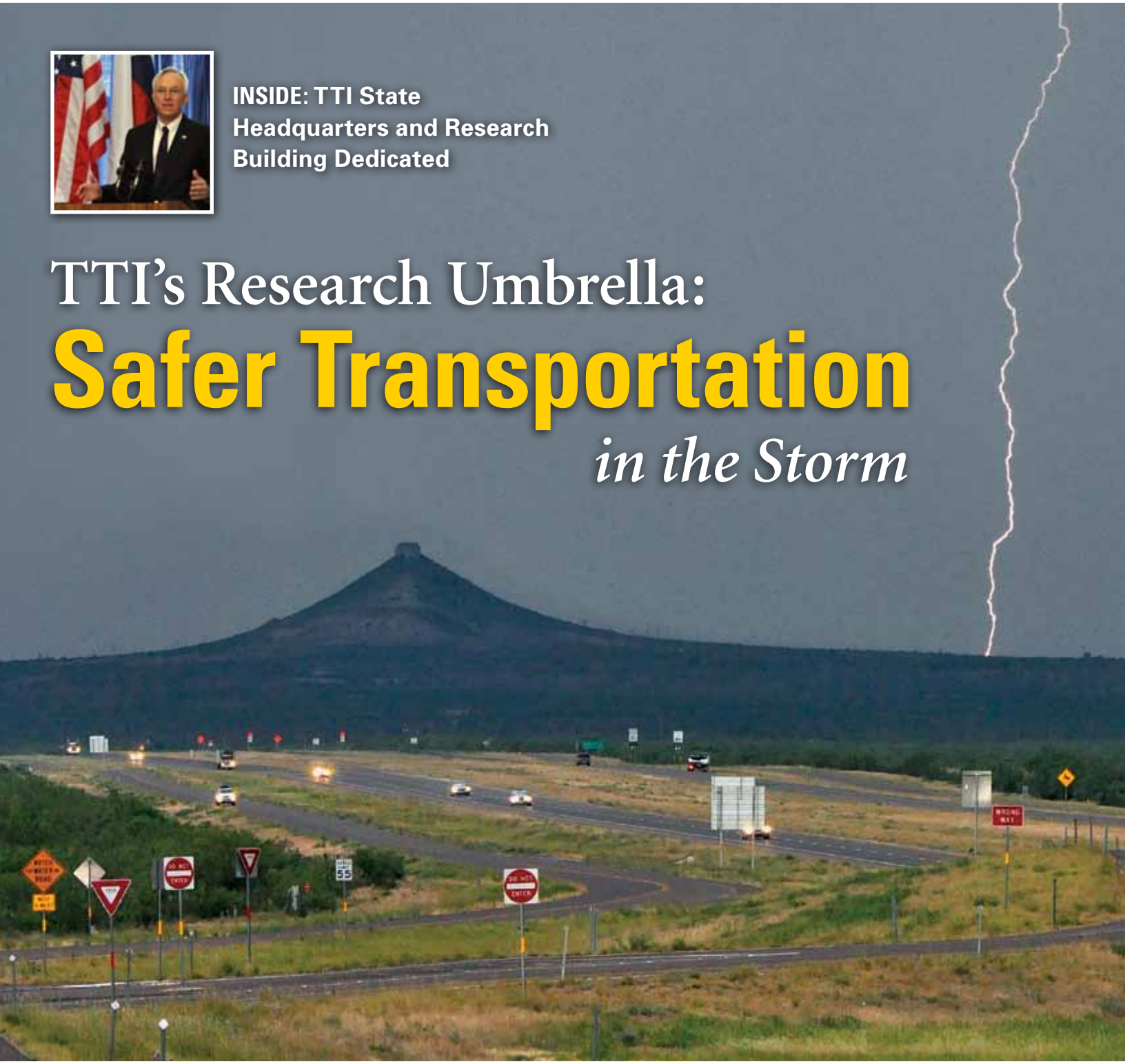
http://tti.tamu.edu

Researcher

VOL. 46 | NO. 2 | 2010

INSIDE: TTI State Headquarters and Research Building Dedicated

TTI's Research Umbrella: Safer Transportation *in the Storm*



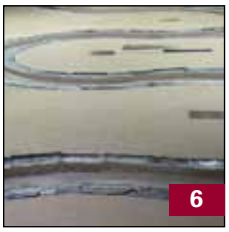
Texas Transportation Institute

A Member of The Texas A&M University System

Research. Service. Results.

ON THE COVER: TTI Photographer Jim Lyle captured this dramatic photo of a lightning strike from an approaching storm along I-10 about 45 miles east of Fort Stockton.

4



6

9

12

TEXAS TRANSPORTATION
Researcher

A PUBLICATION OF

Texas Transportation Institute
Research. Service. Results.
http://tti.tamu.edu

Member

AGENCY DIRECTOR
Dennis L. Christiansen, P.E.

EDITOR
Kelly West

MANAGING EDITORS
Chris Pourteau
Chris Sasser

WRITERS
Michelle Benoit
Rick Davenport
Joanna Dickens
Chris Pourteau
Chris Sasser
Jeremy Smith
Kelly West

DESIGNER
Stacy Schnettler

PHOTOGRAPHER
James Lyle

PROOFREADERS
Michelle Benoit
Beverly Gracia

Texas Transportation Researcher is published by the Texas Transportation Institute to inform readers about its research, professional and service activities. Opinions expressed in this publication by the editors/writers or the mention of brand names does not necessarily imply endorsement by the Texas Transportation Institute or The Texas A&M University System Board of Regents.

Texas Transportation Researcher (ISSN 00404748) is a quarterly publication of TTI Communications, Texas Transportation Institute, The Texas A&M University System, 3135 TAMU, College Station, Texas 77843-3135. For more information or to be added to the mailing list, contact the address below, call (979) 862-6993 or e-mail Susie Catalina at s-catalina@tamu.edu. Periodicals postage paid at College Station.

TTI.RESR1004.0610.4500

POSTMASTER, PLEASE SEND ADDRESS CHANGES TO:
Texas Transportation Researcher
Texas Transportation Institute
TTI Communications
The Texas A&M University System
3135 TAMU
College Station, TX 77843-3135

TTI Has You Covered — *Weather You're Coming or Going*

There's an old joke in Texas: if you don't like the weather here, wait five minutes.

Texas weather varies greatly across the 268,820 square miles of the state. We have five distinct regions, conveniently named North, South, East, West and Central Texas, and each one is known for a unique weather aspect — frozen roads in the north, sweltering heat in the west, hurricanes in the south, tornadoes in the east and pounding thunderstorms in Central Texas. Variety seems to be the only consistent thing about Texas weather.

> Variety seems to be the only consistent thing about Texas weather. That variety challenges the ability of agencies to operate and maintain all types of transportation systems. Research plays a key role in helping address these challenges.

That variety challenges the ability of agencies to operate and maintain all types of transportation systems. Research plays a key role in helping address these challenges. No matter how strong the highway, Mother Nature is always stronger. Time is on her side. Eventually the sun will bake that asphalt until it cracks. Water creeps in during winter and freezes, further splitting the roadway until it crumbles entirely, threatening motorist safety.

When it comes to safety, signage is just as important. On a clear night with a full moon, it's easy enough to see signs warning you to slow down before that sharp curve ahead. During a thunderstorm, it becomes much harder to see those signs. And, like the roadway, time and the sun also wear down signs so they no longer reflect headlights properly.

Researchers at the Texas Transportation Institute (TTI) study the interaction of weather and our transportation system. In this issue, you'll learn some of the ways TTI research is helping to extend road life and protect motorists.

For example, our researchers are finding solutions to common problems, like asphalt cracking and "bleeding" (when excess asphalt binder is pushed to the pavement surface, covering the aggregate). Predicting how raised pavement markers and other retroreflective signs operate under real-world conditions is key to maximizing both the life of the sign or marker and optimizing safety for motorists. TTI's new State Headquarters and Research Building houses a state-of-the-art Visibility Research Laboratory, where the effects of weather on signs and markers can be tested for sponsors nationwide.

Thanks to the TTI-developed software MEANDER, transportation agencies can now predict the future location of rivers as rain, erosion and time alter their courses. Knowing these changes helps agencies better plan for maintenance needs on nearby structures. And with its innovative research into the use of Bluetooth® technology to track traffic flow, the Institute will help save lives by assisting regulatory agencies in choosing the best evacuation routes during a hurricane.

Everything's bigger in Texas — even our tall tales. So maybe the weather doesn't really change every five minutes, but if you live here, it certainly seems that way. Expecting the weather to change that quickly motivates TTI researchers to come up with solutions that are just as flexible.

So, as you read this issue, how's the weather where you are? Is it posing a challenge to keeping the transportation system mobile and safe? Give us a call — maybe TTI can help. All we need is five minutes of your time. »

by Dennis Christiansen
Agency Director

SPOTLIGHT: The Visibility Research Laboratory

The Visibility Research Laboratory features a 125-foot-long corridor, which is used to test materials for traffic signs and pavement markings. The facility also has capabilities to measure vehicle headlamps, sign lighting and roadway lighting.

"A dark and stormy night" is more than a clichéd way to introduce a story — it's a dangerous driving scenario when the visibility of road signs becomes critical for safe passage.

Nighttime traffic fatality rates are three times higher than their daytime equivalents. While fatigue and alcohol play important roles in nighttime crashes, Texas Transportation Institute (TTI) researchers Paul Carlson and Jeff Miles focus on optimizing visibility to help reduce crashes at night.

For over a decade, TTI has developed innovative ways to improve visibility in nighttime driving and played a major role in standardizing visibility test methods. That dedication to finding solutions has paid off with the grand opening of TTI's Visibility Research Laboratory, located on the first floor of TTI's new State Headquarters and Research Building.

"TTI has a long history of nighttime visibility research with field equipment and human factors studies, but this lab provides a whole new way to conduct and develop standardized testing," says Carlson, head of TTI's Operations and Design Division. "We now have better control of the variables so we can develop new test methods and standards."

> "This lab expands our technical capabilities and has the potential to bring in new research partners, including the development of specifications and test methods for other countries and designing and testing experimental materials with private industry. It will open the door to expand and diversify our research."
>
> *Paul Carlson, TTI Researcher Engineer*

The lab is the first of its kind in a university setting. Previously, researchers stayed up most of the night to conduct visibility studies at the Texas A&M University Riverside Campus while relying on Texas weather to cooperate. Now, with the 125-foot tunnel-shaped facility, those same researchers can run night simulations under controlled conditions at any time during the day. An adjacent conference room provides space for presentations, where sponsors and visitors can examine samples of reflective materials with microscopes.

The lab features a custom goniometer — an instrument with a light source on one end and a frame that adjusts along three different axes on the other. The frame supports the material being tested, such as a stop sign. When the angle changes, a computer records the changing optical data as the light retroreflects off the sign. Researchers can

test the retroreflectivity of materials for traffic signs and pavement markings, as well as measure the visibility properties of all types of vehicle headlamps, sign lighting and roadway lighting.

"The benefit of this system and this lab is being able to test 1,001 different samples in a short amount of time to narrow down to a few that we'll then take out into the field," says Miles, an assistant research engineer for the Signs and Markings Program. "The goniometer makes testing different geometries quick, accurate and effective."

One current project uses pavement stripes to test retroreflective optics for night driving to develop new testing methods for state department of transportations that will lead to more consistent quality on the road. In conjunction with new nationwide standards of minimum retroreflectivity maintenance levels for traffic signs, researchers are also using the lab to produce step-by-step guidelines to construct calibration signs near the minimum maintenance levels for nighttime inspections, which will help transportation agencies cost-effectively stay in compliance with the new national standards. Another project starting soon will test how light-emitting diode (LED) technologies could be used in traffic signs in the United States. LED lights are prominently used in signs in other countries, but more research on how to best incorporate LED lighting into traffic signs is needed before they can be adopted by the United States.

"This lab expands our technical capabilities and has the potential to bring in new research partners, including the development of specifications and test methods for other countries and designing and testing experimental materials with private industry," says Carlson. "It will open the door to expand and diversify our research."

The research possibilities are numerous since other TTI divisions and Texas A&M University departments can also access the lab. Talks are underway about a possible master's-level class for the Civil Engineering Department. Human factors studies are being planned for the summer. Also in the future, field instruments could be calibrated in the controlled conditions. The lab currently has the ability to be used for evaluating existing rain measurement test methods but could be modified to study the impacts of fog and rain under a large range of nighttime conditions.

"When drivers travel at night, they rely heavily on the visibility of traffic control devices to reach their destination safely. TTI's new Visibility Research Lab is a first-class facility that can be used to help answer technical questions related to the nighttime visibility needs of drivers," says Greg Schertz, retroreflectivity team leader for the Federal Highway Administration. "Ultimately, we hope that leads to solutions for the huge disparity in the severe crash rates of nighttime versus daytime."

MORE INFORMATION
For more information, please contact Paul Carlson at (979) 847-9272 or paul-carlson@tamu.edu.

Retroreflection 101

- **"Retroreflectivity"** describes how a surface reflects light directed back toward the source.
- **"Luminance"** means the brightness of a sign. Too much luminance produces the "blooming effect" — when the contrast between the darkness around the sign and light retroreflecting from a sign blurs the letters together, making it hard to read.
- **Pavement paints** (the stripes on the road) contain micro-sized glass spheres that help drivers see where they are going. The glass beads — so small that a jar full of them looks like powder — retroreflect the light from headlamps to the driver's eyes. But when the glass beads get wet, their ability to retroreflect light is severely diminished, if not completely lost.
- **Retroreflective raised pavement markers** (RRPMs) — the roadway bumps some drivers make sport of avoiding when changing lanes — supplement pavement paints specifically for wet driving conditions. The life span of an RRPM is less than 18 months.

Time Measured in Raindrops:

TTI Software Predicts River Migration Patterns

Most of us know the time of day by glancing at our watches or cell phones. But another way to tell time is to watch nature itself. For example, you know winter is just around the corner when you see birds flying south.

The above series of images depicts the creation of the river meander lab, which helps researchers predict changes in a river's path.

Would it surprise you to learn that rivers migrate too? While that process unfolds much more slowly than birds making their way to summer homes, it happens all the same.

Rivers carve out their own courses by eroding their banks and, following heavy rains, sometimes overrunning them. Over time these phenomena change a river's path. Nature is flexible enough that such changes really don't impact it much — nature adjusts. But when river migration threatens nearby man-made structures, it's a different story.

"Highway bridges and other near-bank structures can be severely undermined when a river changes its course," explains Texas Transportation Institute (TTI) Research Engineer Hamn-Ching Chen. "Having a way to accurately predict a river's path would be a great help in planning how to troubleshoot such problems."

Chen and his team developed a method for estimating river migration distances and forecasting the future location of rivers. They examined the erosion patterns of four rivers in Texas — the Brazos, Nueces, Trinity and Guadalupe — to better understand factors influencing river migration.

Researchers created a three-dimensional simulation to depict water-flow velocity and shear stress within a curved channel. They then put their modeling to the test using a large-scale flume to examine erosion effects of two different soils (sand and clay) to represent a river's natural process.

Different channel geometry and flow conditions were examined in what might be the largest-scale flume tests performed to date. The team conducted 18 tests in sand and 8 tests in clay. Since the factors affecting migration are numerous (and nature itself is notoriously unpredictable), researchers used risk analyses to determine possible future river paths. The team developed a computer program, MEANDER, which bases its output on water, soil and geometry input, to automate the prediction process.

"While perfect predictability isn't possible, the program produces a risk map based on the data entered," explains Chen. "This map shows the river's current course and possible future courses, each of which is assigned a probability value."

While not conclusive, the results can give agencies like the Texas Department of Transportation (TxDOT) a clue as to what structures might be endangered by Mother Nature. TxDOT can then use this data to better plan maintenance activities strategically, thereby improving service and ensuring safety for Texans that use those structures.

"This program gives us a new tool to use in planning ahead," explains Tom Dahl, design resource coordinator for TxDOT's North Region Support Center. "And better planning means we can analyze and manage the risks of river migration in both design and maintenance of our transportation systems, rather than simply reacting to migration problems after the fact."

Related Publications:

- *Establish Guidance for Soils Properties-Based Prediction of Meander Migration Rate,* 0-4378-1
- *Establish Guidance for Soils Properties-Based Prediction of Meander Migration Rate, 0*-4378-S

MORE INFORMATION
For more information, please contact Hamn-Ching Chen at (979) 847-9468 or hcchen@civilmail.tamu.edu.

Using Bluetooth Technology to Aid in Hurricane Evacuation

In August and September 2005, Hurricanes Katrina and Rita created many disturbing realities for Gulf Coast states, including the need for safely evacuating large numbers of coastal residents. Five years later, planning and implementation of improved hurricane evacuation information systems using Bluetooth® technology are emerging in Texas.

After these storms highlighted areas for improvement in evacuation plans and procedures, researchers at the Texas Transportation Institute (TTI) began working with Texas Department of Transportation (TxDOT) personnel on improving all transportation aspects of the evacuation process. TTI researchers Michael Vickich and Darryl Puckett have developed a Bluetooth travel-time monitoring system for supporting evacuation monitoring. By providing important data about traffic flow on evacuation routes in rural areas, the system will enable transportation officials to make better decisions during evacuation scenarios.

"Prior to this system, decision makers were put in a very difficult situation when having to choose whether to deploy contraflow or not during evacuations," explains Tony Voigt, a TTI research engineer. "The new system will give state officials very good information about real-time traffic conditions in the rural areas on evacuation routes, including at what rate traffic is flowing, which will enable them to make more informed choices than in the past."

Currently this system is being implemented along I-45 from Houston to Dallas, Texas. This stretch of highway is over 225 miles long and will have Bluetooth device readers placed between 5- and 20-mile intervals, but typically between five and 8 miles apart. This system will work by reading the unique identifier (called a media access control [MAC] address) that each Bluetooth device transmits within a short range as it passes by the antennas.

As vehicles equipped with enabled Bluetooth devices pass by successive device readers, the system matches the MAC addresses and then determines average travel time and speed between the points on the roadway. In an evacuation scenario, this technology will be instrumental in providing an accurate representation of what travel times and average speeds are in rural areas along the highway. With this information, decision makers can make informed decisions, such as whether or not to deploy contraflow or how to respond to incidents.

"The information this system provides for rural areas during evacuation scenarios is tremendous, but its capabilities do not end there," says Darrell Borchardt, senior research engineer with TTI. "Travel-time information will be available 365 days a year on roadways equipped with the system, which will provide motorists current information about how incidents or other weather-related conditions are impacting travel times."

A bird's-eye view of a typical rural travel-time monitoring installation mounted on a luminaire pole. The inset photo shows a close-up of the prototype monitoring equipment.

Other important benefits of this technology include a low-cost, low-maintenance way to anonymously collect travel time and speed data. MAC addresses do not contain any personal information and are not directly associated with a specific user.

"TTI's expertise helped us prove that Bluetooth technology can efficiently and accurately provide segment speeds and travel time data," says David Fink, TxDOT transportation operations engineer with Houston TranStar. "The traffic information we can now gather in rural areas will better prepare us for countless scenarios — just one of which is hurricane evacuations."

MORE INFORMATION

For more information, please contact Tony Voigt at (713) 686-2971 or t-voigt@tamu.edu.

For more information on Houston TranStar, please visit http://traffic.houstontranstar.org.

Removing Excess Asphalt

Initial test of ultra-high-pressure water blasting a success

Clumps of asphalt removed from the roadway are visible in this photo. The asphalt was removed using ultra-high-pressure water jets sprayed onto the roadway.

> "Bleeding or flushing occurs when excess asphalt binder is pushed to the pavement surface, covering the aggregate. What you will see is a black and frequently sticky surface, which can lead to a loss of skid resistance."
>
> *Cindy Estakhri, TTI Research Engineer*

Summertime in Texas means rising temperatures, long days and the emergence of maintenance forces ready to take on approximately 186,000 lane miles of roadways. The Texas Department of Transportation (TxDOT) spends over $2 billion annually to maintain the state's roadways, and seal coats are an important part of TxDOT's preventative maintenance program. But what happens when the *maintenance* needs maintenance?

A recent test demonstration led by Darlene Goehl, P.E., a pavement and materials engineer in the TxDOT Bryan District, sought to find a cost-effective option for correcting "bleeding" or "flushing," which is a common problem with seal coats and surface treatments in Texas.

"Bleeding or flushing occurs when excess asphalt binder is pushed to the pavement surface, covering the aggregate," explains Texas Transportation Institute (TTI) Research Engineer Cindy Estakhri. "What you will see is a black and frequently sticky surface, which can lead to a loss of skid resistance."

The demonstration project was conducted on a half-mile stretch of road in Grimes County, Texas. The process involved using a truck called the "Blaster Vac" that sprays ultra-high-pressure water at 36,000 psi onto the flushed roadway surface to remove excess asphalt. The water and asphalt residue are then vacuumed up.

The effectiveness of the water pressure test is evident in the above before and after photo.

"This is the first time ultra-high-pressure water blasting technology has been used in Texas for treatment of flushed seal coats," said Goehl. "We picked a test section that exhibited heavy flushing across the roadway, not just in the wheel paths. It truly is a worst-case scenario type of road that is able to give us a true measure of how this technology works."

The treatment width of the Blaster Vac sprayer and vacuum deck is 2 feet, and after one pass the observers were able to notice a significant amount of excess asphalt removed from the roadway surface.

"One of my concerns was that the water would blast not only the asphalt, but also the aggregate down to the base," said Goehl. "This test showed that not to be the case, and that the aggregate was not removed with the excess asphalt."

The Blaster Vac demonstration is a first step toward implementation of findings from TxDOT research project 0-5230, a study about short-term solutions to "bleeding" asphalt pavements led by Texas Tech University Assistant Professor of Civil Engineering William Lawson, P.E.

In observing the Blaster Vac demonstration, Dr. Lawson noted that the ultra-high-pressure water cutting treatment not only helped to restore the macrotexture of the seal-coat by removing excess asphalt, but also improved the microtexture of the exposed seal coat aggregate. "This will further improve friction resistance for these applications," said Lawson.

TxDOT will monitor the Grimes County test section to determine if water blasting is a cost-effective method to remove excess asphalt and improve the friction characteristics of the pavement.

"Certainly this test is encouraging," said Goehl. "This technology has the potential to save the state time and money by performing maintenance on a roadway instead of having to do a full resurfacing of the pavement."

MORE INFORMATION

For more information, please contact Cindy Estakhri at (979) 845-9551 or c-estakhri@tamu.edu.

TxDOT personnel inspect the roadway after a pass from the ultra-high-pressure water truck.

"This year we mark 60 years of excellence at TTI, which had a leading role in the design and safety of our highways, the financing of our transportation projects and the study of our traffic patterns to help us relieve congestion. Within these walls important research will take place that will save lives by improving the quality of our transportation system."

Morris Foster,
Chairman of The Texas A&M University System Board of Regents

Supporters Turn Out for State Headquarters and Research Building Grand Opening

The grand opening celebration for the Texas Transportation Institute's (TTI's) first state headquarters building March 26 not only highlighted the past accomplishments of the Institute's 60-year history but also the crucial work yet to be done.

"Quite frankly, this new facility is clearly the envy of our peers," Agency Director Dennis Christiansen told the 200 people in attendance. "It provides us with facilities that are unmatched anywhere else in the country for the kind of work we do."

The 66,700-square-foot TTI State Headquarters and Research Building (SHRB) houses a state-of-the-art Visibility Research Laboratory designed to test devices and materials used for pavement markings and traffic signs (see related story on page 4). Real-world visibility conditions can be simulated in the lab, allowing researchers to explore ways of making driving at night safer. Nighttime fatalities outpace daytime fatalities by a three-to-one margin.

"Some 250 to 300 people lose their lives in this senatorial district each year in traffic crashes," noted State Sen. Steve Ogden, a champion of transportation safety. He received a standing ovation when he was introduced at the event.

TTI employees and invited guests gather around to hear TTI Director Dennis Christiansen's remarks during the grand opening celebration.

Left: Texas Sen. Steve Ogden spoke about TTI's contributions in making Texas highways safer.

TTI Advisory Council members and members of the grand opening stage party gather around a changeable message sign declaring the SHRB open for business.

Amadeo Saenz, TxDOT Executive Director, speaks about the importance of the TTI research program.

Ogden told the crowd that Texans have a right to expect that our roads are as safe as possible. "The work that you do here will save lives today and in the future," he said. "My hat is off to you. There is no more important task out there."

Other speakers at the grand opening celebration included Morris Foster, the Chairman of The Texas A&M University System Board of Regents; Michael McKinney, the Chancellor of The Texas A&M University System; TTI Research Engineer Paul Carlson; David Cain, President of David Cain Consulting; and Amadeo Saenz, the Executive Director of the Texas Department of Transportation (TxDOT).

"This year we mark 60 years of excellence at TTI, which had a leading role in the design and safety of our highways, the financing of our transportation projects and the study of our traffic patterns to help us relieve congestion," Foster told the crowd. "Within these walls important research will take place that will save lives by improving the quality of our transportation system."

TTI Research Engineer Paul Carlson discusses signage with Institute of Transportation Engineers International Vice President Robert Wunderlich.

"Who would have imagined that some 60 years later that decision would have led to countless lives being saved and innovations that made TTI and TxDOT transportation leaders in the country? Safety innovations like crash cushions, sign supports, traffic barriers…these are just some of the things you'll see going down the highway, and most were developed by a TTI research program and have been implemented by TxDOT, making our highway system safer."

Amadeo Saenz, TxDOT Executive Director

The new State Headquarters and Research Building in College Station is next door to TTI's Gibb Gilchrist Building — where many of the agency's research staff and laboratories are located — creating a campus-like atmosphere for the Institute. TTI also operates research and testing facilities at the Texas A&M University Riverside Campus, offices and laboratories in the CE/TTI Building on the main campus of the university, and urban offices in Arlington, Austin, Dallas, El Paso, Galveston, Houston and San Antonio, Texas.

"TTI is an integral symbol of Texas A&M System engineering excellence," said McKinney. "This is the 60th year they have had a positive impact on transportation in Texas and throughout the world through their work in finance, construction and safety."

Since it was established six decades ago, TTI has become known worldwide for its safety innovations, congestion and mobility studies, and research related to all modes of transportation.

"By any measure, for over 60 years TTI has been a leader and innovator in transportation research such as roadside safety, mobility, data collection and interpretation, urban congestion, environment, education — the list goes on and on," said Cain.

"We are fortunate to have the support of everyone in this room at a time when transportation has never been more important," Christiansen said.

During his comments at the celebration, Saenz told the crowd of his support for the Institute as he reflected on the TTI/TxDOT partnership that was formalized by the Texas Legislature in the late 1940s.

"Who would have imagined that some 60 years later that decision would have led to countless lives being saved and innovations that made TTI and TxDOT transportation leaders in the country?" Saenz said. "Safety innovations like crash cushions, sign supports, traffic barriers…these are just some of the things you'll see going down the highway, and most were developed by a TTI research program and have been implemented by TxDOT, making our highway system safer."

MORE INFORMATION

For more information, please contact Terri Parker at (979) 862-8348 or t-parker@tamu.edu.

Cracking under Pressure:

How Moisture and Heat Affect ASR and DEF Structures

Texas weather runs the gamut — cold winters in some areas, occasionally heavy rains, times of drought and always baking summer heat. Concrete structures are built to last, but it's the little things that get you sometimes. Little things like moisture and heat over time can trigger reactions in concrete structures that cause cracking and ultimately deterioration.

Two reactions in concrete that are most troubling are alkali-silica reactions (ASR) and delayed ettringite formation (DEF). ASR occurs when the alkalis in concrete react with the silica in some aggregates (the rocks included in concrete). Moisture can feed this reaction, which causes expansion with time and cracking. The other reaction, DEF, occurs between sulfate in gypsum in the cement and calcium aluminates when calcium hydroxides are present. Heat and moisture cause the growth of crystals, which can also cause the concrete to crack.

"It seems to be the cycle of wetting and drying that causes the most damage with ASR," says Zachary Grasley, a research scientist with the Texas Transportation Institute (TTI) and an assistant professor in the Zachry Department of Civil Engineering at Texas A&M University, who is studying these processes. "ASR can cause a distributed cracking pattern, called map cracking because it looks like lines on a map when you look at the surface of the concrete. DEF, on the other hand, can form much larger cracks." Both deterioration mechanisms tend to create

The D-region of a concrete frame displays cracking that might be amplified by ASR/DEF deterioration. TTI research is investigating the effect this cracking has on structural performance.

cracking in areas of concrete members that are in tension.

Texas Department of Transportation (TxDOT) research has helped develop specifications to minimize the risk of ASR and DEF, but older structures built before the new specifications were in place can be affected by them. Current TTI research is evaluating the structural performance of lap splices (overlapped steel reinforcing bars) in deteriorated bridge columns (project 0-5722) and the structural performance of critical D-regions (areas of complex stress distribution) of concrete frames (project 0-5997) that are damaged by ASR and/or DEF.

"TxDOT's job is to manage infrastructure, and in order to spend money wisely, we need to quantify the problem by seeing how much the structural integrity is affected," says John Vogel, a senior bridge design engineer with TxDOT's Houston District. "Just because a column looks bad doesn't mean it really is. This project will give us the tools we need to manage the problem."

The first phase of the project, constructing and deteriorating test specimens with a range of crack sizes from these reactions, is underway at TTI's Riverside Campus. The second phase of the project will be to load these specimens to failure and compare their performance to that of specimens with undamaged concrete. Researchers will then be able to correlate the structures' physical appearance with their structural strength and reliability.

"The testing we're doing right now at Riverside involves inducing ASR and DEF in concrete structures," says the principal investigator, Joe Bracci, TTI assistant research engineer and professor in Texas A&M's Zachry Department of Civil Engineering. "The concrete specimens get 15 minutes of water four times a day using a sprinkler system and get exposed to Texas heat to simulate the cycle of wetting and drying. Internal strain gages take measurements and surface expansion data every two weeks."

Cracking from ASR or DEF may reduce the bond between the concrete and the reinforcing steel. Structures can face significant demands at several locations where bond is critical. Severe deterioration in these locations could ultimately lead to a failure in overload scenarios — and a disaster for the entire structure. TxDOT's primary concern is safety; TTI research should identify if the deterioration conditions create any structural performance issues that need to be dealt with.

"The results of this research could have a huge financial impact," says Vogel. "The only 'cure' for ASR and DEF is waterproofing, which slows down expansion. Not having to waterproof structures would save TxDOT funds."

Vogel points to a waterproofing project TxDOT performed in November 2007. TxDOT paid $10,000 to $20,000 per column for waterproofing. Other ongoing research should reduce the cost to half what TxDOT paid in 2007, but that's still a considerable sum.

"The affected concrete in the Houston area alone is on the order of tens of millions of square feet," says Vogel. "I hope and believe that the current research will show that waterproofing is not necessary at all, letting us spend our limited resources wisely elsewhere."

"It seems to be the cycle of wetting and drying that causes the most damage with ASR. ASR can cause a distributed cracking pattern, called map cracking because it looks like lines on a map when you look at the surface of the concrete. DEF, on the other hand, can form much larger cracks."

Zachary Grasley,
TTI Research Scientist

"The testing we're doing right now at Riverside involves inducing ASR and DEF in concrete structures. The concrete specimens get 15 minutes of water four times a day using a sprinkler system and get exposed to Texas heat to simulate the cycle of wetting and drying. Internal strain gages take measurements and surface expansion data every two weeks."

Joe Bracci,
TTI Assistant Research Scientist

Concrete specimens are exposed to wetting and drying cycles by a sprinkler system at the TTI Riverside Campus to accelerate deterioration from ASR/DEF.

MORE INFORMATION
For more information, please contact Joe Bracci at (979) 845-3750 or j-bracci@tamu.edu.

NOW

Marking the Way

Research project improves performance of raised pavement markers

"RRPM failures are not only a public safety issue, but also expensive when you take into consideration having to close the roads for repairs. With the results of this research, we were able to recommend that TxDOT emphasize the quality of RRPM installation since we found it directly relates to performance in the field. And they are also now able to better predict the life expectancy of these markers for all types of roadways and traffic volumes."

Yunlong Zhang,
TTI Assistant Research Scientist

The worst of driving conditions calls for the best of roadway markers. And with their reflective properties, retroreflective raised pavement markers (RRPMs) have guided many nervous drivers safely to their destination on rainy nights. That's why RRPMs' durability and performance are of critical importance to the Texas Department of Transportation (TxDOT).

A few years ago, though, TxDOT began to notice an increased number of RRPM failures such as poor retention on pavements, physical damage and loss of retroreflectivity. In some cases, mass failures occurred when an entire section of RRPMs disappeared only weeks after installation. In response to this problem, the Texas Transportation Institute (TTI) began to research the causes of premature RRPM failures.

"All the markers that TxDOT was using met the requirements set by ASTM specifications," says Yunlong Zhang, TTI assistant research scientist and research supervisor "However, RRPMs' performance varied significantly, and the results from existing testing methods also did not correlate with field performance. We were asked to identify or develop new lab testing methods that would help us to more accurately predict marker performance in the field."

Over a three-year period, researchers conducted multiple tasks that included lab and field tests, as well as surveying TxDOT districts and RRPM manufacturers to gather information on existing test procedures and marker field performance.

This pavement marker shows several failures on the shell. These failures could be caused by something as simple as a stone wedged in the tire tread of a vehicle.

"For two years we monitored four test deck locations that were selected based on traffic condition and pavement type," says Zhang. "For example, one of our test decks was on the 610 Loop in Houston, which is a very high-volume concrete roadway. We also had a test deck on a low-volume road with a flexible pavement surface. The goal was to get a wide range of test data in different scenarios."

The research yielded several important findings with respect to RRPM performance and testing methods:

- Performance of RRPM products has a wide range and depends on traffic volume, truck traffic and pavement surface type.
- Retroflectivity degrading is directly related to average daily traffic.
- High truck traffic significantly accelerates marker physical damage.
- Marker retention is directly related to installation quality.
- Current testing methods were inadequate and cannot predict field performance of the markers.

Another important finding was that the results from the developed pendulum impact test (see sidebar) had a sound correlation with that of field performance, giving TxDOT a proven marker quality-control tool.

"RRPM failures are not only a public safety issue, but also expensive when you take into consideration having to close the roads for repairs," says Zhang. "With the results of this research, we were able to recommend that TxDOT emphasize the quality of RRPM installation since we found it directly relates to performance in the field. And TxDOT is also now able to better predict the life expectancy of these markers for all types of roadways and traffic volumes."

> "The researchers did a great job of modeling the forces on a pavement marker from vehicular impact. This was cutting-edge work."
>
> *Darren Hazlett, TxDOT Construction Division*

"The researchers did a great job of modeling the forces on a pavement marker from vehicular impact. This was cutting-edge work," said Darren Hazlett, with the Construction Division at TxDOT and project director. "They also produced a pendulum impact test that could be used to test markers and have transferred this test equipment to us."

MORE INFORMATION
For more information, please contact Yunlong Zhang at (979) 845-9902 or yzhang@civil.tamu.edu.

Pendulum Impact Test

During the project, the team discovered that many of the failures of retroreflective raised pavement markers (RRPMs) began with the fracture of the outside shell. These failures could be caused by something as simple as a stone wedged in the tire tread of a vehicle. Consequently, failure occurred due to the impact of a hard small object with the surface of the RRPM.

"What we needed was a testing procedure that evaluated the ability of the RRPMs to absorb energy-of-impact type loading," says Yunlong Zhang, research supervisor. "Since there was nothing that existed, we designed and fabricated the pendulum impact test device."

The pendulum impact device is a nifty piece of equipment that allows users to test the durability of the RRPM outer shell using different weights. The RRPM is clipped into place, and a weighted arm swings down and impacts the marker. Different weights can be added to the end of the pendulum arm to increase the force exerted on the marker at impact. The marker support is adjustable, so four different impact points can be tested to give a full evaluation.

"We tested six RRPMs with this device using all six weight configurations at each of the four impact positions," says Zhang. "Using this device to test markers before they are installed will give TxDOT a better idea of the durability and performance they can expect, particularly in high-traffic areas."

Related Publications:

- *Development of Measures to Improve Field Performance of Retroreflective Raised Pavement Markers*, 0-5089-1
- *Raised Pavement Marker Improvements*, 0-5089-S

THEN

TTI's Contributions to Pavement Marking Started Early

The Hot-Melt Plastic Stripe as a Pavement Marking Material

By Charles J. Keese

(Excerpted from Bulletin No. 130, Texas Highway Department, March 1953)

"PAINT IS THE STRIPING MATERIAL FOR THOUSANDS OF MILES OF STREETS AND HIGHWAYS. However, its resistance to wear and weathering is so poor, that frequent maintenance of stripes is necessary. Such maintenance is costly.

Recent experimentation has produced an easily applied plastic road marking material of good durability.

It is rosin-alkyd resin which can be compounded in either white or yellow color and applied to pavement in hot-melt form. Preliminary tests have indicated a service life of several times that of standard paints on both asphalt and concrete pavements.

Highway technologists have expressed such keen interest in the material that specifications are being made available in this publication. Trade names are mentioned only as necessary to identify ingredients.

It is hoped such information shall be useful in providing greater serviceability from our streets and highways while at the same time reducing striping maintenance costs."

Above: A forerunner of today's automated striping machinery, the hand-powered machine was used for laying the hot-melt plastic paint stripe. It consisted of a tricycle cart, gasoline heating unit, oil-bath kettle, metal screed box (held firmly to the pavement by springs) and a wooden attachment for applying reflectorizing beads.

The thermoplastic pavement striper was invented at the Texas Transportation Institute(TTI) in the early 1950s. Jack Keese and his research team employed an innovative use of sulphur and heat with the paint.

TTI and IBM Partner for Intelligent Transportation Solutions

In a collaboration that could lead to future transportation improvements in Texas and around the globe, leaders from the Texas Transportation Institute (TTI) and IBM signed a memorandum of understanding (MOU) during a ceremony in Austin April 1.

"This agreement is a starting point that allows us to take university-based research across the world in partnership with a highly regarded organization," Agency Director Dennis Christiansen said at the ceremony, which was held at IBM's Austin facilities. "We're excited about this; the possibilities for working together are unlimited."

Christiansen and Texas A&M University System Chancellor Mike McKinney signed the agreement alongside executives from IBM.

Known as the world's biggest technology company, IBM employs more than 400,000 people and conducts research at eight laboratories worldwide, including its facility in Austin. IBM holds more patents than any other U.S.-based technology company.

The non-binding collaboration combines the efforts of both parties in exploring technological advancements in the area of intelligent transportation solutions. The parties will work together on data fusion and integration, accident prevention, environmental protection, travel-time reliability, traffic prediction and technologies for mobile computing.

Representatives from IBM, TTI and The Texas A&M University System gather for a picture during the signing of the MOU April 1.

"TTI's credibility in transportation research, coupled with IBM's global reach and investment in smarter planet solutions, are an ideal combination to work collaboratively on worldwide transportation issues," John Drewry, IBM Corporation client executive, said regarding the affiliation. "Going forward, we will be working together to proactively secure government funding to pursue joint research programs, create technology breakthroughs via TTI, IBM research and academic partners, including the incubation and piloting of promising technologies in the real world."

IBM executives and managers from across the country attended the ceremony. TTI attendees included Ginger Goodin, manager of TTI's Austin Office; Associate Director Ed Seymour; and Assistant Director Christopher Poe. Texas A&M University System Vice Chancellor for Federal Relations and Commercialization Guy Diedrich was also present.

"I am excited about the future," McKinney said at the signing ceremony. "Despite being known for our traditions, the A&M System and TTI's research programs are focused on the future. We are looking forward to working collaboratively and creatively with IBM researchers in supplying benefits to the people of Texas and the rest of the world." ■

Christiansen Receives Prestigious ITE Honor

In its highest recognition of notable and outstanding professional achievement, the Institute of Transportation Engineers (ITE) awarded Texas Transportation Institute (TTI) Agency Director Dennis Christiansen with honorary membership. Christiansen becomes ITE's 77th Honorary Member.

"Dr. Christiansen has demonstrated his leadership and dedication to the transportation profession as a former Texas District director on ITE's Board of Direction and as a past international president," ITE International Vice President Robert C. Wunderlich said during the ceremony.

"Dr. Christiansen's research findings and those of TTI continue to improve the quality of life in Texas, the United States and throughout the world," Wunderlich, who began his career at TTI, said. "Thanks to this work, our roadways are safer, more efficient, more sustainable and better able to meet the needs of all users."

Christiansen has extensive research experience in several areas, including traffic operations and transportation planning, and is an international expert in high-occupancy vehicle lanes. ■

ITE International Vice President Robert Wunderlich congratulates Dennis Christiansen after presenting him with ITE's 77th honorary membership.

Preventable Traffic Deaths Examined at CTS Conference

Several speakers at the 2010 Traffic Safety Conference shared the tragedy of losing a loved one with the 200 people attending the second statewide forum organized by the Texas Transportation Institute's (TTI's) Center for Transportation Safety (CTS). The conference, with the theme "Putting the Pieces Together," was held in Dallas March 29-31.

"One of the things that struck me in this conference is how easy it is to talk about over 35,000 lives lost [the number of U.S. traffic fatalities in 2008]," said Agency Director Dennis Christiansen. "But the number of people we had at the conference who had the personal experience of loss in their family puts a very human face on this."

Christiansen moderated the final session of the conference, which touched upon distracted driving, motorcycle safety, changing the driving culture, wrong-way driving, red-light cameras and — the subject that seemed to dominate the discussion — drunk or impaired driving.

"My husband was killed by a wrong-way, impaired driver in 1991 about 15 miles from here," Laura Dean-Mooney, the national president of Mothers Against Drunk Driving (MADD), told the attendees. "This is the reason I came to MADD and the reason I continue to do what I do…so other families don't get impacted like mine was." According to the National Highway Transportation Safety Administration, impaired driving accounted for almost 40 percent of the total 2008 Texas fatalities.

"It's an embarrassing thing to think we have so many fatalities related to DWI and at the same time knowing there is a remedy to this… but we are not willing to take the steps necessary to correct it," State Sen. John Carona said during the round-table discussion about sobriety checkpoints. "This [legislation allowing Texas to conduct them] is long overdue."

TTI Associate Research Scientist Patty Turner talks to conference participants.

Speakers said that sobriety checkpoints could save an estimated 400 lives each year in Texas through deterrence.

"It's quite offensive to me that the failure of state lawmakers to act prevents local communities from doing what we know works better than any other law enforcement tool in saving lives," State Rep. Todd Smith said during the conference. Smith has repeatedly authored legislation to allow checkpoints, but the bills never make it out of committee for a vote. "We have a lot of people in this state who believe there is a right to drive while drinking. I don't know how to explain that."


Laura Dean-Mooney, national president of MADD, gives a presentation on impaired driving.

The Traffic Safety Conference brought together traffic experts, policymakers, law enforcement and researchers with "a common interest in traffic safety but [who] bring very different approaches, skills, information and tools to solve the puzzle that is traffic safety," Christiansen said.

The ultimate goal of the forum was to share the latest information about what is killing and injuring motorists in Texas and ways to reduce those numbers.

House Transportation Committee Vice Chairman Rep. Larry Phillips lost a college roommate in a traffic crash. "We have got to work together to change the culture of safety in Texas," he said during the conference. "It's a huge task. We've got to start sometime. How about now?" ■

CTS Advisory Council Meets in College Station

Advisory council members of the Texas Transportation Institute's (TTI's) Center for Transportation Safety (CTS) were briefed on current efforts, past accomplishments and future initiatives during their all-day meeting at the Gibb Gilchrist Building Feb. 3. "You are essential to what we do," Agency Director Dennis Christiansen told the members. "It's important that we get your guidance and input."

The 10 CTS Advisory Council members meet every 18 months. They represent law enforcement, public health, state and federal government, municipalities, insurance agencies, transportation engineering and education. Their expertise in various fields helps direct the center's actions.

CTS Director John Mounce provided the members with an overview of the center including its history, current and past activities, staff and structure. "The Safety Center's mission is to effect a reduction in travel fatalities and injuries sustained by motorists on Texas highways and serve as a focal point for research, education and collaboration to achieve that goal," he said. "There has been a declining number of fatal traffic crashes in Texas since the inception of the Safety Center."

Mounce told the members that the center's current initiatives involve traffic law enforcement, vulnerable road users, distracted driving, changing the traffic safety culture and implementation of highway safety corridors. ■

Transportation Hall of Honor Inducts Port Pioneer

A man responsible for the development of the Texas port system has been posthumously inducted into the Texas Transportation Hall of Honor as its 31st member. The Texas Transportation Institute (TTI) established the Hall of Honor in 2000 as a way to recognize the state's leaders in transportation.

The children of Frank H. Newnam, Jr., were presented the award during the 75th anniversary celebration of Lockwood, Andrews and Newnam, Inc. (LAN), a Houston-based engineering firm in which Newnam was a partner.

"The TTI Hall of Honor Board is pleased to honor Frank Newnam, who is the epitome of a Texas transportation pioneer," said Agency Director Dennis Christiansen. "During his 28-year career at LAN, he developed the original Port of Houston master plan, master plans for other major ports in Texas and the first master plan for the George Bush Intercontinental Airport. His significant contributions have shaped multiple modes of travel throughout our state."

Newnam was a 1931 graduate of Texas A&M University, where he was enrolled in the ROTC program. He spent 10 years with the Texas Highway Department before being called into active duty with the U.S. Army Corps of Engineers in the China Theater.

After retiring from the Corps of Engineers in 1946, Newnam joined the engineering firm of Lockwood and Andrews and became a company partner. Through his work, Newnam streamlined and modernized the shipment of goods and services at Texas ports.

"On behalf of Lockwood, Andrews and Newnam, we are proud to accept this prestigious award from TTI honoring one of our founders," said LAN President Dennis Petersen.

Pictured at the induction ceremony for Frank Newnam are (left to right) LAN President Dennis Peterson, sons of the honoree Albert Newnam and John Newnam, and TTI Agency Director Dennis Christiansen.

"His accomplishments and leadership formed a solid foundation for the firm, which we continue to build on today. It was doubly rewarding that we could celebrate the award and LAN's 75th anniversary at the same event."

Newnam's granddaughter, MaryAnn Newnam Wright, spoke at the ceremony. "Frank (grandpa) was a down-to-earth man — well spoken, understated, articulate and funny," she said. "Thank you, TTI, for recognizing his talents and gifts as an engineer. He never needed awards or looked for them, but would surely have appreciated this type of recognition from the state he so dearly loved, Texas." ■

Reiley Retires, Is Recognized for Service

Cathy M. Reiley, associate vice chancellor for external relations and Regents Fellow, was honored for 18 years of service to the Texas A&M Engineering Program during her retirement ceremony May 13.

Pictured with Reiley are (left to right) G. Kemble Bennett, vice chancellor and dean of engineering; TEEX Director Gary Sera; and TTI Agency Director Dennis Christiansen.

In her position, she represented the Texas Transportation Institute (TTI), the Texas Engineering Experiment Station (TEES), the Texas Engineering Extension Service (TEEX) and the Texas A&M University Dwight Look College of Engineering in state and federal relations.

In addition to representing TTI in the state and federal legislative arenas and following transportation-related legislation affecting the Institute, Reiley played a key role in obtaining funding for all of TTI's state exceptional items. She was instrumental in the creation of the Center for Transportation Safety, Center for Ports and Waterways, Strategic Transportation Solutions Center and Center for International Intelligent Transportation Research in El Paso, Texas.

"Cathy has exemplified class and professionalism in leading the Institute's legislative efforts, and we will sorely miss her insightful and steady guidance over many years," said Dennis Christiansen, TTI agency director. "Her understanding of the political process, keen judgment and excellent decision making are unmatched in her profession. We owe her a great debt of gratitude for all she has done to move TTI forward."

Reiley's many accomplishments include securing $1 million in state matching funds for the Southwest University Transportation Center, a transportation research and education consortium with TTI as the lead institution. Other consortium partners are The University of Texas at Austin and Texas Southern University. ■

TEXAS TRANSPORTATION
Researcher

Texas Transportation Institute/TTI Communications
The Texas A&M University System
3135 TAMU
College Station, TX 77843-3135

Periodicals
Postage
PAID
College Station
Texas 77843

TEXAS TRANSPORTATION INSTITUTE

Publications

TECHNICAL REPORTS

"Development of Decision-Making Support Tools for Early Right of Way Acquisitions," by Paul Krugler, **0-5534-2**, May 10, 2010.

"Development of the Texas Revenue Estimator and Needs Determination System (T.R.E.N.D.S.) Model," by David Ellis, **0-6395-TI-1**, May 12, 2010.

"Evaluation of Barriers for Very High Speed Roadways," by Roger Bligh, **0-6071-2**, March 26, 2010.

"Guidelines for Signal Operations at Intersections with Wide Medians," by Srinivasa Sunkari, **0-6176-1**, March 23, 2010.

"Guidelines for Spacing between Freeway Ramps," by Kay Fitzpatrick, **0-5860-1**, April 8, 2010.

"Guidelines for the Use of Pavement Marking Symbols at Freeway Interchanges: Final Report," by Brooke Ullman, **0-5890-1**, April 26, 2010.

"Integrating the Transportation System with a University Campus Transportation Master Plan: A Case Study," by Rafael Aldrete-Sanchez, **0-6608-2**, April 26, 2010.

"New Generation Mix Designs: Laboratory Testing and Construction of the APT Test Sections," by Lubinda Walubita, **0-6132-1**, April 6, 2010.

"Preserving the Functionality/Asset Value of the State Highway System: Technical Report," by Ed Hard, **0-6208-1**, March 15, 2010.

"Roadside Sediment Control Device Evaluation Program: Technical Report," by Jett McFalls, **0-5948-1**, April 8, 2010.

"Seal Coat Damage Evaluation Due to Superheavy Load Moves Based on a Mechanistic-Empirical Approach," by Jeongho Oh, **0-5270-1**, April 8, 2010.

"Site Specific Wave Parameters for Texas Coastal Bridges: Final Report," by Jun Jin, **0-6063-1**, May 7, 2010.

"Synthesis of Current Research on Permeable Friction Courses: Performance, Design, Construction, and Maintenance," by Kai-Wei Liu, **0-5836-1**, March 17, 2010.

"Water Retention Techniques for Vegetation Establishment in TxDOT West Texas Districts," by Jett McFalls, **0-5748-1**, April 6, 2010.

"Internal Trip Capture Estimator for Mixed-Use Developments," by Brian Bochner, **5-9032-01-1**, April 6, 2010.

"Platoon Identification and Accommodation System Implementation in Brownwood and Caldwell, Texas," by Nadeem Chaudhary, **5-5507-01-1**, March 29, 2010.

"Potential Development of an Intercity Passenger Transit System in Texas: GIS Maps," by Curtis Morgan, **0-5930-P2**, April 9, 2010.

"Potential Development of an Intercity Passenger Transit System in Texas — Final Project Report," by Curtis Morgan, **0-5930-2**, May 17, 2010.

PRODUCTS

"Alternative Pavement Design Analysis Tool (APDAT)," by Carlos Chang-Albitres, **0-6085-P1**, March 25, 2010.

"Guidebook on Preserving the Functionality of State Highways in Texas," by Ed Hard, **0-6208-P1**, May 7, 2010.

"Handbook: Guidelines for Successful Location and Accommodation of Major Distribution Centers on Texas Highways," by Brian Bochner, **0-5335-P1**, April 27, 2010.

"Integrating the Transportation System with a University Transportation Master Plan," by Rafael Sanchez, **0-6608-P2**, April 2, 2010.

"Internal Trip Capture Estimator," by Brian Bochner, **5-9032-01-P1**, April 6, 2010.

"PIA System Installation and User Guide: 2009 Update," by Hassan Charara, **5-5507-01-P3**, April 20, 2010.

"PIA System Software Version 2.2," by Nadeem Chaudhary, **5-5507-01-P2**, April 16, 2010.

"RAP Workshops," by Fujie Zhou, **0-6092-P1**, April 9, 2010.

"Site Specific Wave Parameters for Texas Coastal Bridges: Software," by Jun Jin, **0-5335-P3**, April 28, 2010.

"Teaming for Success — TxDOT Is Here to Help," by Brian Bochner, **0-5840-P1**, April 20, 2010.

"TxDOT Can Help Pave the Way for Distribution Centers," by Brian Bochner, **0-5335-P2**, April 16, 2010.

"Video Library for Video Imaging Detection at Intersection Stop Lines," by Dan Middleton, **0-6030-P1**, April 30, 2010.

TTI PUBLICATIONS

A full catalog of TTI publications and other products is online at http://tti.tamu.edu/publications. You can find the publications by searching for either the title or publication number listed here. Most of these publications are available as free downloads in portable document format (PDF).

Printed, bound versions of these reports are also available through the URL above.