By Joanna Dickens, Chris Pourteau and Chris Sasser
Contributing Authors

Raised question

TTI tests the durability of pavement markers

The worst of driving conditions calls for the best of roadway markers. With their reflective properties, retroreflective raised pavement markers (RRPMs) have guided many nervous drivers safely to their destination on rainy nights.

The durability and performance of RRPMs are critically important to departments of transportation nationwide. A few years ago, the Texas Department of Transportation (TxDOT) noticed an increased number of RRPM failures resulting from 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.

"All the markers that TxDOT was using met the requirements set by ASTM specifications," said Yunlong Zhang, a Texas Transportation Institute (TTI) assistant research scientist.

"However, RRPM 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 more accurately predict marker performance in the field."

Over a three-year period, TTI 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.

Researchers also monitored four test-deck locations for two years. The decks were chosen based on their traffic condition and pavement type to provide a range of test data under different conditions. One test deck was on the 610 Loop in Houston, a high-volume, concrete roadway. Another was on a low-volume road with a flexible pavement.

"RRPM failures are not only a public safety issue, but also expensive when you have to close the roads for repairs," said 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."

Swinging pendulum

During the project, the team discovered that many of the failures of RRPMs began with the fracture of the outside shell.

These failures could be caused by something as simple as a stone wedged in a vehicle's tire tread. Consequently, failure occurred due to the impact of small, hard objects 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," said Zhang. "Since there was nothing that existed, we designed and fabricated the pendulum-impact test device."

The pendulum-impact device allows users to test the durability of the RRPMs 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 on impact. The marker support is adjustable, so four different impact points can be tested to give a full evaluation. The results of using this test correlate strongly with RRPM field performance.

"We tested six RRPMs with this device using all six weight configurations at each of the four impact positions," said Zhang. "Using this device to test markers before they are installed will give TxDOT a better idea of the durability and

During the project, the team discovered that many of the failures of RRPMs began with the fracture of the outside shell.

performance they can expect, particularly in high-traffic areas."

The next step is for TxDOT to test the device across the state and see how it performs in terms of assessing quality control for qualifying RRPM products. Potentially the device could take the place of TxDOT's more traditional ball-drop test, which involves a more complicated procedure and produces less consistent results. Other states, specifically Ohio and Louisiana, are interested in the device as well.

"The researchers did a great job of modeling the forces on a pavement marker from vehicular impact. This was cutting-edge work," said Project Director Darren Hazlett of TxDOT's Construction Division. **R&B**

The authors are technical writers for the Texas Transportation Institute.

TTI's Visibility Research Laboratory

Nighttime traffic fatality rates are three times higher than their daytime equivalents. While fatigue and alcohol play important roles in nighttime crashes, 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," said 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."

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-ft 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 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," said Miles, assistant research engineer for TTI's Signs and Markings Program. "The goniometer makes testing different geometries quick, accurate and effective."

Visibility-related research conducted at TTI has resulted in key safety improvements. For instance, TTI led the research that ultimately led to the new Clearview font on highway guide signs. TTI research also produced recommendations for the Federal Highway Administration (FHWA) for their recent rule-making efforts related to the introduction of minimum maintained sign retroreflectivity levels in the Manual on Uniform Traffic Control Devices (MUTCD).

The Visibility Research Laboratory is currently proving instrumental as TTI investigates new technologies for enhanced visibility of the nighttime roadway. In one project, TTI is evaluating how light-emitting diode (LED) technologies can best be used in traffic signs. LED lights are prominently used in signs in other countries, but more research on how to best incorporate them into traffic signs is needed before the U.S. can adopt them.

"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," said Carlson. "Since we opened the lab, we have expanded our research portfolio and are now developing and evaluating new retroreflective coatings and other technologies to assist nighttime drivers."

The research possibilities are numerous, since other TTI divisions and Texas A&M University departments also can access the lab. Talks are under way about a possible master's-level class for the Civil Engineering Department. 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.

Greg Schertz, retroreflectivity team leader for the FHWA, believes TTI's facility will have an important impact on improving safety for nighttime drivers. "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. Ultimately, we hope that leads to solutions for the huge disparity in the severe crash rates of nighttime versus daytime."