COLORADO DEPARTMENT OF TRANSPORTATION

Research Newsletter

Spring 2008

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Bird Roosting and Nesting Deterrents

The sky is not really falling. It's pigeons up there, dropping their loads. There are also swallows swooping in and out of box culverts and under bridges, feeding their young, and keeping our engineers waiting for months to clean, repaint, and replace the structures. The droppings corrode the steel and concrete and can be a safety concern on our bridges and to our cleaning staff. The swallows and their nests are protected by the Migratory Bird Act until the fledglings have flown and left their parents (empty nesters). What's a DOT to do?

We're taking the upper hand. Our research team is studying ways that pigeons can be convinced to roost elsewhere, and for swallows to find alternate nesting places for a season. The pigeons can be deterred best through design of structures that do not provide them with flat horizontal surfaces on which to roost. Other possible deterrents include spikes and wires. A coating of slippery paint can be used where droppings cannot be avoided, to prevent structural corrosion and make cleaning easier.

The swallow nesting deterrents are a little different. These need to keep the birds from attaching their nests to the 90-degree angle at the tops of culvert walls and bridge components. Our team is planning to test some of the best deterrents this spring. We are installing several products in three box culverts just before nesting season. One product includes a plastic hanging curtain installed just a few inches from the side wall. Its presence and flapping should discourage the birds' nesting. Two other products involve covering the 90-degree angle with a long piece of fiberglass or plastic, one with a triangular profile and one that is curved. Finally, we will paint the top of one culvert a sky blue color, to see whether something this simple can keep the birds away.

We will watch the culverts all spring and summer and decide in the fall which ones worked the best.

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Swallow nests under a bridge deck

Relationship Between Safety and Number of Lanes on Urban Freeways

The Problem

Decisions to add travel lanes on a freeway are motivated by the need to provide capacity. It is generally believed by the practicing engineers and planners that decreased congestion afforded by additional lanes is associated with some degree of improved safety, yet the majority opinion among researchers is that the accident rates increase with increase in the number of lanes. What effect the number of lanes has on safety is a practical question that was not well understood until recently. It was raised in the course of a major transportation study in the Denver Metro area in connection with comparing design alternatives from a safety standpoint.

CDOT Research staff, in cooperation with Staff Traffic, explored this question by comparing Safety Performance Functions (SPFs) calibrated for multilane freeways with different numbers of lanes. SPFs are accident prediction models that relate traffic exposure, measured in AADT, to safety, measured in the number of accidents over a unit of time (accidents/mile per year). The data for the development of accident prediction models came from Colorado, California and Texas. The results of this comparison are quite interesting.

Comparison of the SPFs of multilane freeways in Colorado, California and Texas suggests that adding lanes may initially result in a temporary safety improvement that disappears as congestion increases. As Annual Average Daily Traffic (AADT) increases, the slope of SPF, described by its first derivative, becomes steeper, reflecting that accidents are increasing at a faster rate than would be expected from a freeway with fewer lanes.

Possible Explanation

Increase in the slope of SPF associated with increase in the number of lanes may possibly be explained by the increase in the number of potential lane-change-related conflict opportunities. According to the Highway Capacity Manual (HCM), *the number of lanes on a freeway segment influences Free Flow Speed (FFS). As the number of lanes increases, so does the opportunity for drivers to maneuver around slower traffic.* Increased maneuverability tends to increase average speed of traffic, but at the same time it increases speed differential as well as the number of lane-change-related crashes such as sideswipes and rear-ends. The number of possible conflicts in one direction is a function of the number of lanes on the freeway. We have examined the number of possible permutations of lane-change-related conflicts for each number of lanes and identified the following generic relationship:

$$C_n = f(n) = n(n-1) + (n-2)^2$$

C_n - Number of possible lane-change-related conflicts in one direction

n - Number of lanes in one direction

A 4-lane freeway with 2 lanes in one direction will have a potential for only 2 possible lane-change-related conflicts in each direction.

$$C_2 = f(2) = 2(2-1) + (2-2)^2 = 2$$

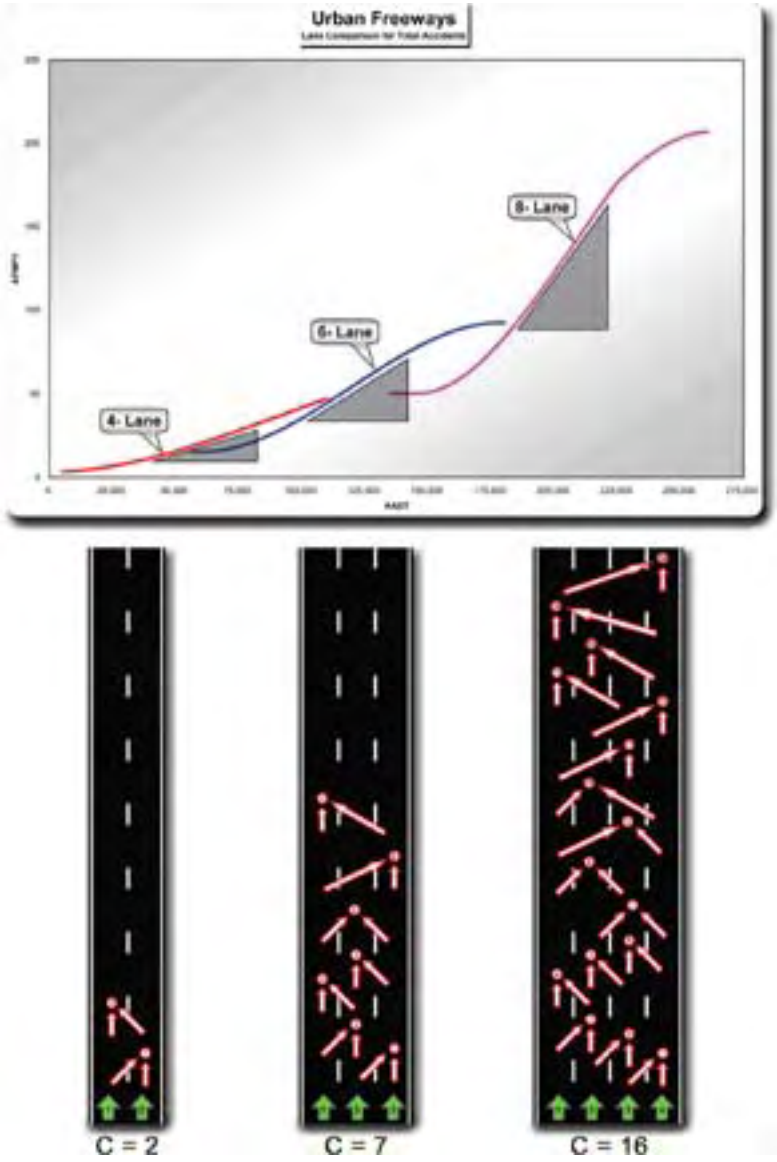

Figure 1 Number of Lanes and Number of Lane-Change-Related Conflicts for 4, 6, and 8 Lanes SPF

A 6-lane freeway with 3 lanes in one direction will have a potential for 7 possible lane-change-related conflicts in each direction.

$$C_3 = f(3) = 3(3-1) + (3-2)^2 = 7$$

An 8-lane freeway with 4 lanes in one direction will have a potential for 16 possible lane-change-related conflicts in each direction.

$$C_4 = f(4) = 4(4-1) + (4-2)^2 = 16$$

Figure 1 is a graphical representation of the connection between the slope of SPF and the number of possible lane-change-related conflicts. It approximates what will happen when the same road is widened from 4 to 6 to 8 lanes with all other things being equal. Additionally it illustrates a direct relationship between the number of lanes and the number of possible lane-change-related conflicts. Clearly not all conflicts have the same probability of occurrence; however, additional lanes increase the degree of freedom for things to go wrong.

Deterioration of safety associated with increase in the number of lanes has the following important implication: *Introduction of HOV lanes, managed lanes including toll, or planning dual-dual roadways may be more effective than widening of general purpose lanes. During the design phase, however, it is critical to ensure that interface between managed lanes and general purpose lanes is carefully laid out to minimize turbulence related to merging and diverging.*

It is reasonable to suppose that widening in the urban environment is generally triggered by a high degree of congestion. Once additional capacity is provided through widening the traffic density is temporarily decreased. **Figure 2** illustrates this phenomenon for the widening from **n** to **n+2** lanes. This decrease in traffic density is associated with a more forgiving driving environment reflected by the temporary safety improvement. **Figure 2** shows that the same amount of traffic on **n+2** lanes in the overlap zone will generate fewer crashes than on **n** lanes at the same level of AADT. As development occurs in concert with rerouting of traffic from other routes, the critical density of traffic on the route with **n+2** lanes will be reached and it will then exhibit higher accident rates than observed on **n** lanes manifested by the steeper slope of the SPF.

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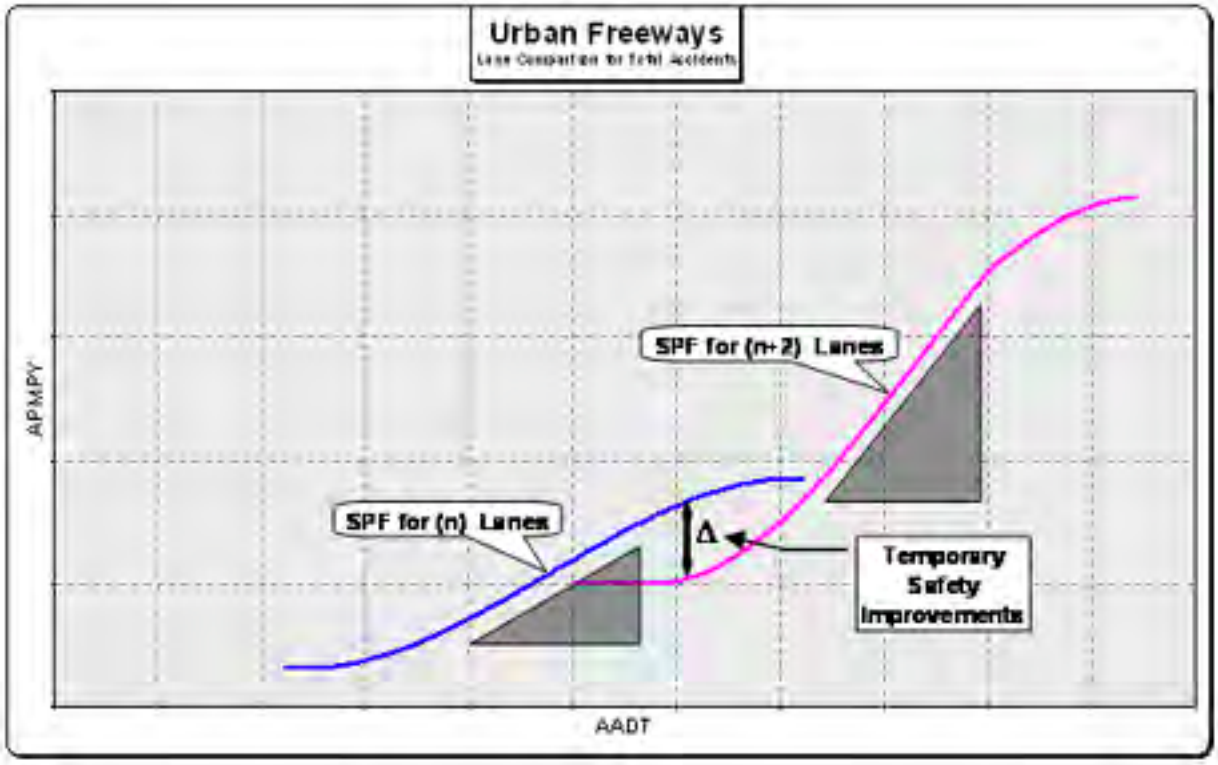


Figure 2 Transition between SPF

This article reflects research findings presented at the 2008 TRB Annual Meeting; the resulting paper has been accepted for publication by the Transportation Research Board of the National Academies.

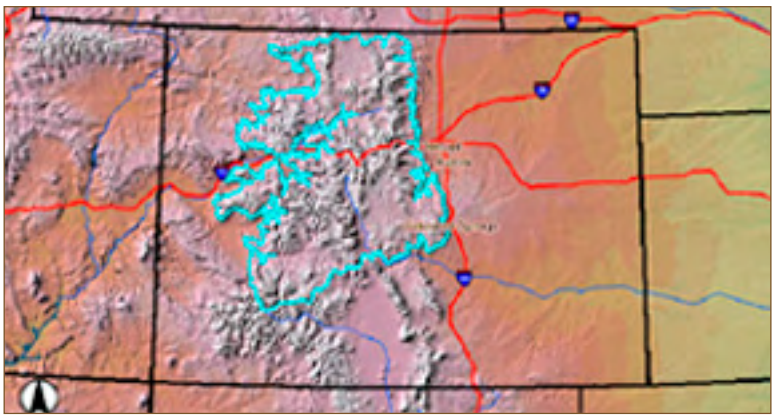
StreamStats: An Interactive Web Tool

CDOT needs information about streamflow characteristics of Colorado rivers and streams for design and correct sizing of culverts and bridges. Estimates of the magnitude and frequency of flood-peak discharges and flood hydrographs are also used for flood control structures and the management and regulation of flood plains. At gaged sites, statistics can be obtained from existing publications. However, estimates are more commonly needed at ungaged sites where no observed flow data are available. Manual methods to determine streamflow statistics are slow and resource intensive and may produce results that are not reproducible.

The US Geological Survey (USGS) has developed an interactive map-based web application (StreamStats) for determining streamflow statistics and drainage basin characteristics. Information is customized on a cost-sharing basis for individual states, with a long-term goal of national coverage. StreamStats is an excellent tool that produces fast, accurate, consistent results in printable reports and via shapefiles of delineated basins. Phase I of the Colorado implementation has been completed and streamflow statistics for Western Colorado drainage basins are available online: http://water.usgs.gov/osw/streamstats/colorado.html

Delineated Colorado basin - StreamStats

Phase II of the StreamStats for Colorado implementation has been funded for FY09. It will provide a time-efficient, reproducible, and documented method for estimating peak flows for Eastern Colorado basins. A future Phase III study is planned to complete StreamStats for Western Colorado. The product will be vertically-integrated 1:24,000 scale GIS datasets for the study area (elevation, hydrography, watershed boundaries, base maps, and site locations). These datasets will exist within the ArcHydro framework, which will allow for integration and use in a multitude of water resources projects.



StreamStats for outlined area are available online

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Work Zone Speed Studies

In an effort to improve work zone safety, the Research Branch is analyzing the results of two studies on traffic speed through work zones on divided four-lane highways: *Work Zone Speed Control* and *Work Zone Speed Reduction.* For both studies traffic through the work zone was videotaped in one-hour segments under various conditions. Speed was calculated by counting the videotape frames a vehicle took to travel a measured distance.

Work Zone Speed Control compared traffic speeds in a normal work zone marked by MUTCD signs, cones and arrow board, to speeds through the same work zone with various additions. All scenarios included the normal MUTCD work zone setup reducing the speed limit from 75 mph to 55 mph. Additions included:

- A variable message sign (VMS) flashing the speed of vehicles that exceeded the 55 mph speed limit;
- A Colorado State Patrol (CSP) car in the work zone with its lights off;
- Two CSP cars in the work zone, lights off;
- A single CSP car in the work zone with its lights flashing and a Trooper in the car; and
- Two CSP Troopers operating radar and writing tickets.

Work Zone Speed Reduction evaluated traffic speed through a normal MUTCD work zone. During a day, the speed limit through the work zone was lowered in 5 mph increments from the posted highway speed to the lowest speed allowed by CDOT Maintenance rules. There was no additional signing or law enforcement. At each reduction an hour of videotape shows how fast vehicles actually traveled through the work zone, and how much variation there was in their speeds.

When the study results have been analyzed, we will have a better understanding of what speed reduction produces the most consistent behavior by drivers and the ability to weigh the cost of various additions to work zone traffic control against their effects on compliance with the speed reduction.

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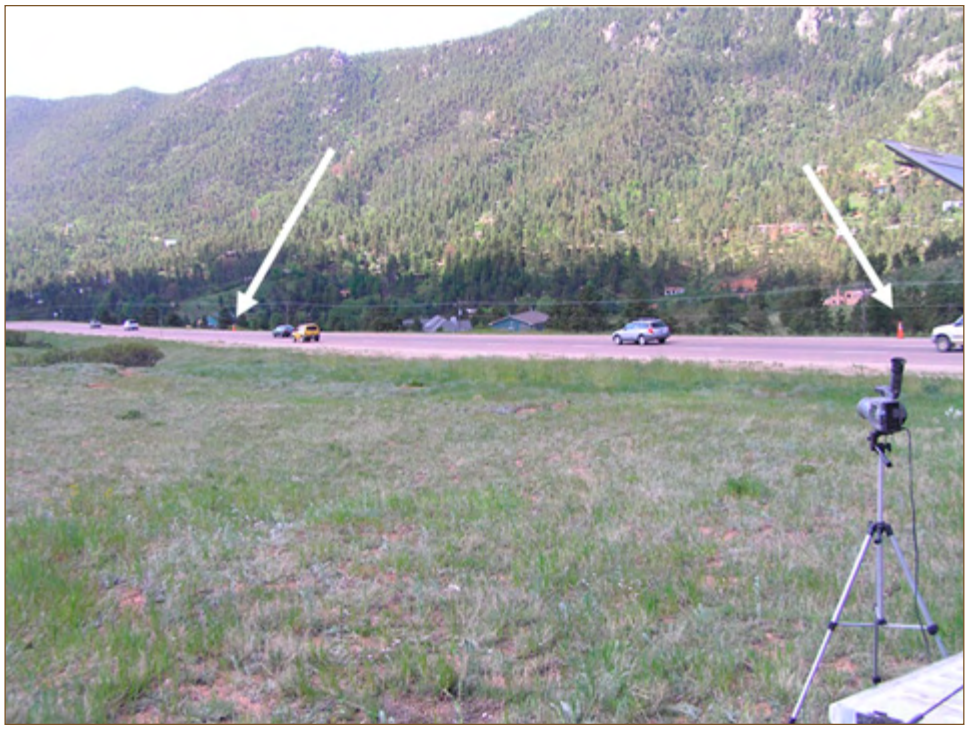

Arrows indicate videotape range

FY09 Approved Research Program Requests

Twenty-one research studies have been approved for the FY09 Research Program, in addition to ongoing studies that were approved for funding in previous years. These are the culmination of many ideas that were submitted by staff, universities, and consultants in Colorado. The technical research oversight teams reviewed all of the research problem statements and submitted their top choices to the Research and Implementation Council (RIC) for funding consideration. The RIC met on February 11 and prioritized the research proposals for funding, pending management's approval. The approved studies are listed in order of their final ranking.

1) Colorado Statewide Historic Bridge Inventory

This study will update the statewide bridge survey, streamline CDOT's historic bridge clearance process, and provide an up-to-date bridge inventory database with user-friendly software.

2) AASHTO Development of DARWin-ME (Pooled-Fund Study)

A fast, easy, streamlined, and user-friendly version of AASHTO's new mechanistic-empirical pavement design software program is needed. As a member agency of the DARWin-ME Task Force, CDOT will have input in the development of the software and users guide.

3) Southeast Superpave Center Participation/National Center for Asphalt Technology (Pooled-Fund Study)

The Center performs asphalt pavement-related research, including pavement noise studies, and provides expert witness services for dispute resolution. With participation in the pooled fund, CDOT will have access to expensive, specialized research equipment and technical expertise.

4) Evaluating the Potential of Aggressive Incident Clearance

The Courtesy Patrol incident clearance program works well. The question is whether it is implemented at the right level, or whether further operational safety benefits could be realized with a more aggressive level of incident clearance.

5) Evaluation of Thin-Bonded Overlays on Asphalt Surfaces with Deicing Properties on I-76 and Weld County Road 53 Structures

There are products on the market that are supposed to replace the wearing surface of asphalt bridge decks and also help with deicing operations. If these claims are substantiated, wearing surface/deicing overlays could be used on future construction and maintenance projects.

6) Denver Area Post-World War II Suburbs

This study will expedite environmental clearances for historical properties in areas with post-World War II suburban developments. The associated GIS database will help CDOT historians and consultants with historical resource surveys.

7) Improving Resilient Modulus (Mr) Test Procedures for Unbound Materials (Pooled-Fund Study)

This research will reduce the variability currently associated with resilient modulus testing of unbound materials and provide assistance to states to establish laboratories for successful testing.

8) Arid Region Revegetation

This project will generate improved revegetation plans and protocol that will be incorporated into Stormwater Management Plans for projects in arid regions with poor native soil.

9) Investigation of the Benefits from Utilizing Small Aggregates for Seals on HMA Roadways

Many highways are located far from ideal HMA aggregate sources. This study will investigate use of river basin aggregate that, with minimal processing, could be used to preserve deteriorating roadway structures.

10) Optimization of Stabilization of Highway Embankment Slopes Using Driven Piles, Phase 1:
Maintenance efforts to stabilize fill slopes with driven piles are carried out with minimal engineering or geotechnical input. A coherent design method based on actual installations is needed.

11) Deterioration and Cost Information for Bridge Management
The product of this research will be an accurate preservation module within the PONTIS software package, calibrated for Colorado bridges, for forecasting bridge conditions and prioritizing projects.

12) Encouraging Innovation by CDOT Workers
The goals of this study are to identify and document all existing innovative devices created by CDOT workers, evaluate each device's potential for widespread use, and foster a climate where ingenuity is rewarded.

13) Construction of Crack-Free Concrete Bridge Decks, Phase II (Pooled-Fund Study)
It should be possible to construct nearly crack-free bridges, if best practices are followed. This study will provide technical support for participating DOTs to implement best practices for improving bridge deck life.

14) Building Noise Walls with Scrap Tires
The deliverables of this project will include effective design of noise walls containing recycled tires, construction and monitoring of the walls, and a research report documenting the findings.

15) Application of Roller Compacted Concrete in Colorado's Roadways
Roller compacted concrete (RCC) has potential for providing an economical alternative to conventional paving materials. Pilot test sections will help CDOT determine RCC's applications to highway construction.

16) Implementation of the Simple Performance Tester (SPT) for SuperPave Validation (Pooled-Fund Study)
Study results will enable CDOT to perform cheaper, reliable, and accurate simple load tests to evaluate permanent deformation and fatigue cracking of SuperPave design mixes.

17) Guide for Implementing Red Light Camera Enforcement and Evaluation of Transportation Safety and Operational Impacts
This study will investigate what characteristics should be present before red light cameras are installed, the pros and cons of camera installation, and alternative countermeasures.

18) Development of New Corrosion/Abrasion Guidelines for Selection of Culvert Pipe Materials, Phase II
Standardized design and retrofit procedures are needed to incorporate corrosion and abrasion factors, with realistic service life estimates, to pipe selection for specific drainage applications.

19) New Design Procedure for Type C and D Inlets (Pooled –Fund Study)
New sizes and design protocol for highway drainage inlets will result in significant costs savings.

20) Sustainable Stabilization of Sulfate-Bearing Soils with Expansive Soil-Rubber (ESR) Technology
This research will provide an alternative method to subgrade soil stabilization that will eliminate problems associated with calcium-based stabilization and support the greening government program.

21) Development of an Internet-based Tool for Estimating Flood Magnitudes, Phase II (StreamStats)
When this cost-sharing effort has been implemented, streamflow statistics and drainage basin characteristics for the entire state of Colorado will be available online.

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Quiet Pavement Research

The FHWA's noise mitigation policy restricts making adjustments for pavement type in the prediction of highway traffic noise levels and using specific pavement types or surface textures for noise abatement. CDOT has elected to conduct a tire-pavement and highway environmental noise research study using Quiet Pavement Research (QPR) to substantiate the use of pavement types and surface textures as noise abatement measures. The goal of this research is to develop and execute a comprehensive, long-term study to determine if particular pavement surface types and/or textures can be successfully used in Colorado to help satisfy FHWA's noise mitigation requirements.

CDOT hired the Transtec Group, Inc., led by Dr. Rob Rasmussen, as the Principal Investigator. Following a rigid set of testing protocols, data is being collected on highway traffic noise characteristics, along with safety and durability aspects of the associated pavements. To date, thirty-one unique pavement surfaces have been evaluated and this information will be used in constructing acoustical durability relationships. Additional testing of these same 31 pavement surfaces is currently scheduled to be performed in 2009 and 2011. The first and second year interim reports will be published this year.

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