TECHNICAL QUARTERLY
"AN EXCHANGE OF IDEAS"

TQ 11-1, March 1997 EDITOR: Kathleen M. Jones

"GALLOPING" SIGNAL ARMS: A METHOD TO DAMP THE MOTION

from Research Report 1303-1F,
Wind Load Effects on Signs, Luminaires, and Traffic Structures,
by **James R. McDonald, Kishor C. Mehta, Walter W. Oler,**
Wind Engineering Research Center
Texas Tech University
and **Narendra Pulipaka,**
Vertex Communications Corp., Kilgore, TX;
excerpted by **Kathleen M. Jones**
Information Specialist II
Research and Technology Transfer Office
Texas Department of Transportation

FIG. 1: An in-service traffic signal structure exhibiting galloping. Photo composite by Michael Gray, Center for Transportation Research.

THE PROBLEM

When high winds from tornadoes and hurricanes damage signs and traffic signal structures, no one is surprised. However, cantilevered traffic signal structures can vibrate (Fig. 1) under certain low-speed wind conditions (4.5 to 13.4 m/s [10 to 30 mph]). The horizontal arm can flex up and down as much as 610 mm (24 inches). Not only is this motion distracting to motorists, it also can fatigue the metal in the mast arm. While fatigue failures are not common, they do occur. For instance, during the course of this research project, a 14.6 m (48-foot) mast arm failed and fell to the ground in Dalhart, Texas, in November 1991. A fatigue crack had developed at the connection of the arm to the vertical pole. Fortunately, no one was injured.

One objective of Research Project TECH 0-1303, ***Wind Load Effects on Signs, Luminaires, and Traffic Structures,*** was to develop ways to stop or reduce large-scale vibrations in single-mast traffic structures, once the reason for the motion was determined. This article will discuss the results of this objective.

THE CAUSE

The Project 0-1303 team at the Wind Research Center of Texas Tech University found that the signal head most at risk was a horizontal one

Published in cooperation with the Federal Highway Administration four times a year by the Texas Department of Transportation, Research and Technology Transfer Office, P.O. Box 5080, Austin, TX 78763-5080.
The *Technical Quarterly* is dedicated to the free flow of ideas and information within the transportation community.

with a back plate. This type is prone to violent motion when the wind is coming from behind. Mast arms with vertical signal heads, even with back plates, do not flex much. Two possibilities are vortex shedding and galloping oscillations.

Vortex Shedding

Vortex shedding means that, in an object's wake, eddies form that rotate in alternate directions. Shear layers on opposite sides of the object cause this rotational change. When a bluff body (like a signal head) sheds vortices, the pressure on each side of the object is reduced and increased alternately. Vortex shedding frequency depends on the cross section of the object and the free wind (or fluid) speed. If the structure's resonant frequency is close to the vortex shedding frequency, motion 90° to the wind direction can be induced.

Water table experiments ruled out vortex shedding alone as the cause of the violent motion in the Texas signal head configuration. These experiments showed a mismatch between the frequency of vortex shedding and the resonant frequency of the signal structure.

Galloping

Why a signal structure will gallop (flex rhythmically and repeatedly) is complex. It depends on signal head shape, arm configuration, wind characteristics (direction, speed, and turbulence), structure stiffness, the natural frequency of the structure, and other factors. Galloping also requires some disturbance to get it going. Traffic wake effects, wind gusts, or vortex shedding are types of disturbance that can induce galloping.

The disturbance produces a change in the aerodynamic forces acting on the signal head. Negative aerodynamic damping changes the apparent wind angle from straight to downward. The signal head is forced downward. As structural stiffness decelerates this downward motion, the apparent wind angle and aerodynamic force return to zero. The structure moves up towards neutral, changing the apparent wind angle to an upward one. Because the aerodynamic force is aligned with the motion, the arm overshoots the neutral position upward. Structural stiffness decelerates this upward motion. The apparent wind angle and aerodynamic force return to zero. The arm moves down towards neutral. The apparent wind angle changes to a downward one. The arm is deflected to below the neutral axis, and the cycle starts over.

Results from towing eight configurations of a full-size, back-plated signal head in Tech's tow tank suggested galloping as the prime cause of the violent motion. (See the sidebar: ***Tech's Tow Tank.***) The complexity of galloping precludes developing predictive or preventive design procedures. Fortunately, there are ways to damp the motion of a traffic signal structure that is known to gallop.

A SOLUTION

The research team conducted field tests at the Wind Engineering Research Field Laboratory. These field tests were to verify the tow tank results and to test the effectiveness of vibration-damping methods. Researchers constructed a rotatable base. When clamped, the base has the same foundation rigidity as a structure in service (Figs. 2 and 3). The rotatable base allowed the researchers to control the wind angle on the signal structure. This control enabled them to use any wind of the right speed, no matter what the direction. Two instrumented signal structures were tested. First, the researchers erected and tested a 12.2 m (40-foot) older type of mast arm (Fig. 4). After they finished testing it, they replaced it with a 14.6 m (48-foot) cantilevered arm structure meeting all current TxDOT specifications.

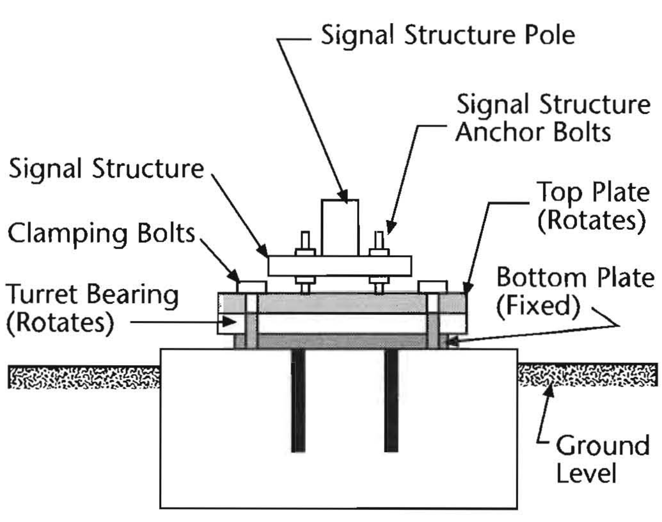


FIG. 2: Foundation schematic for rotatable base.

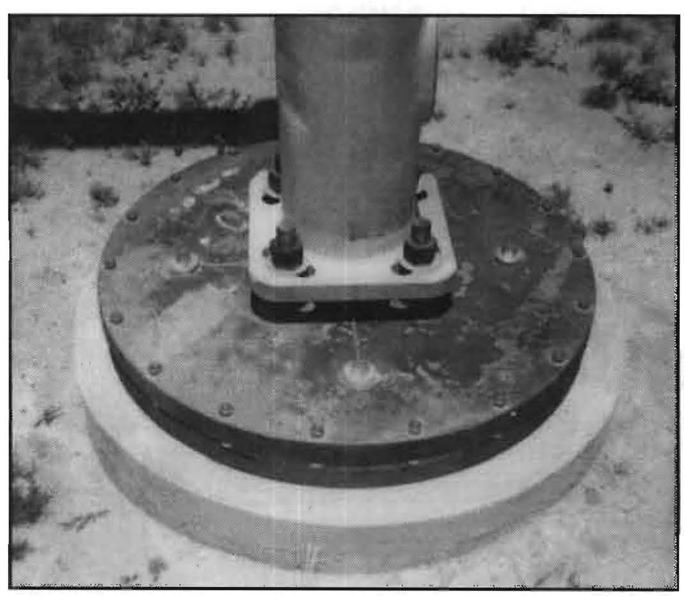


FIG. 3: The finished rotatable base.

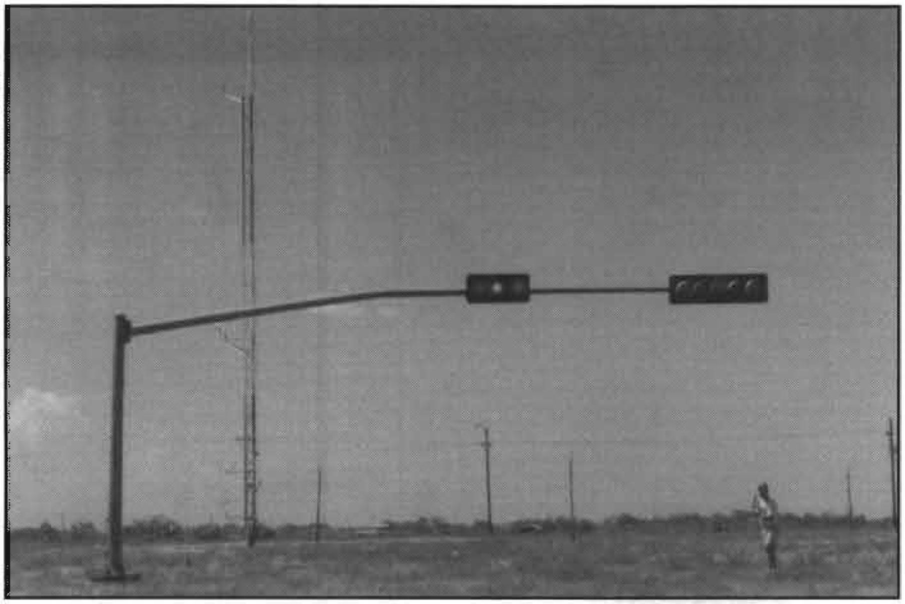


FIG. 4: Overall view of 12.2 m (40-foot) traffic signal structure and rotatable base. Two signal heads have been mounted on the arm. Note meteorological tower in the back ground. This 49 m (160-foot) tower carries instrumentation to measure wind speed, wind direction, temperature, barometric pressure, and relative humidity at five separate elevations.

Field Confirmation

Initial field test data confirmed the tow tank results. Field and tow tank data indicated that configuration 5 (Fig. 5) was the only one prone to galloping. The researchers determined that, once the mast tip deflection exceeds ± 200 mm (± 8 inches), the motion is probably due to galloping, may be distracting to motorists, and may or may not pose a fatigue problem to the structure. Galloping exceeding ± 200 mm (± 8 inches) occurred during the field tests only under a narrow range of conditions:

★ wind blowing from the back side of a traffic signal head in configuration 5

★ wind direction within ± 7.5° normal to the back side of the signal head

★ steady wind speed ranging from 4.5 to 13.4 m/s (10 to 30 mph)

Damping Methods Tried

Using this narrow range of conditions to induce galloping in the 14.6 m (48-foot) arm structure, the researchers tested the effectiveness of three techniques for damping galloping.

★ a **tuned mass damper**, sometimes called a dynamic absorber, a technique frequently used in tall buildings to suppress wind vibrations and earthquake forces

★ a **liquid-tuned damper** that dissipates energy by sloshing water or other liquid. The Japanese have used this method to damp wind-induced vibrations in tall buildings.

★ a **damping plate** (wing). With some success, a few TxDOT maintenance personnel have used damping plates made from horizontal sign blanks.

The tuned mass damper proved impractical to attach to a mast arm. The liquid-tuned damper was a 914 mm (3-foot) piece of PVC pipe partially filled with water that was inserted into the mast arm. It did not dissipate sufficient energy to be effective. In some cases, it increased the vibration amplitude. The researchers do not recommend either of these methods.

Instead, they concentrated their efforts on verifying the concept of the horizontal sign blank damping plate and on determining the optimum size and mounting location. They tried the configuration most often used in the field: a 230 mm by 910 mm (9-by-36-inch) sign blank mounted on a section of bare mast arm away from the signal head. They also tried a 410 mm by 1680 mm (16-by-66-inch) sign blank mounted directly above the signal head. The smaller damping plate mounted away from the signal head was not effective.

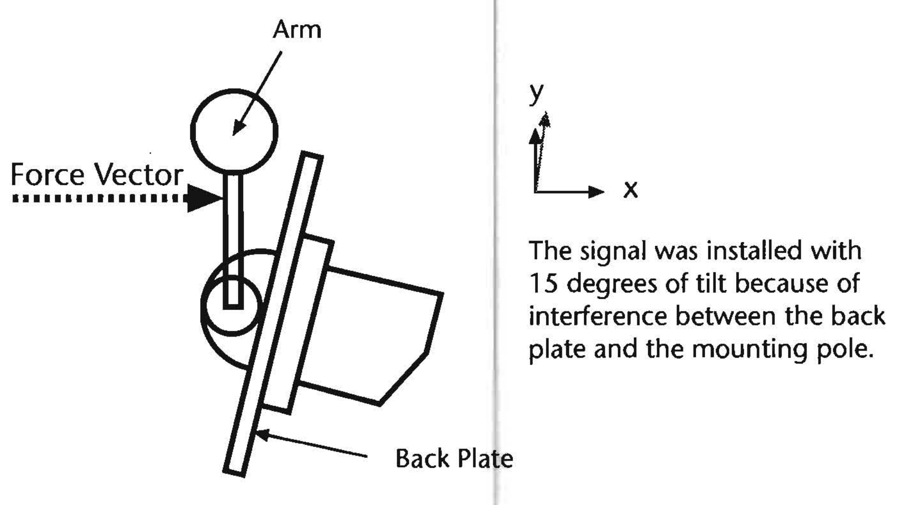


FIG. 5: Tow tank data indicated that this configuration would be the most likely to gallop of all eight configurations tested. Full-scale field tests concurred.

What Worked

The larger sign blank mounted at least 80 mm (3 inches) directly above the signal head effectively damped the galloping motion (Fig. 6). This method has three clear advantages.

- ★ It requires no knowledge of the dynamic characteristics of the existing structure
- ★ Materials are readily available and easily installed by TxDOT maintenance personnel
- ★ A damping plate, since it is edge-on to the line of sight, is not a distraction to motorists

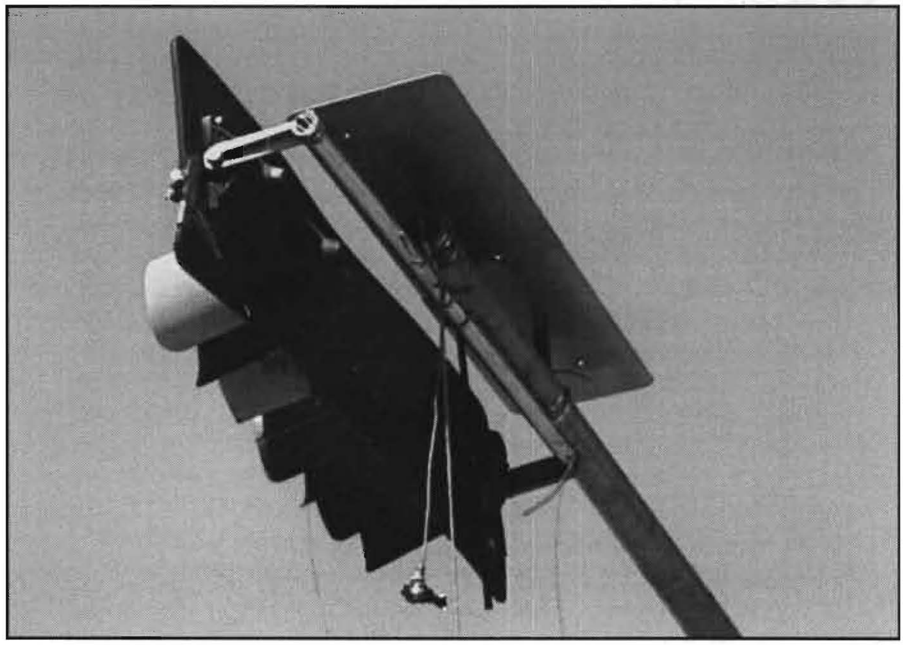


FIG. 6: Large damping plate mounted on signal structure.

CONCLUSIONS

Under certain conditions, single-armed signal structures can "gallop." The free end of the arm may flex up and down as much as 610 mm (24 inches). Galloping can distract motorists and can potentially shorten structural fatigue life.

Galloping depends on the signal head configuration, the natural frequency and stiffness of the structure, and the wind environment. Currently, engineers cannot practically predict with certainty whether a particular signal structure will gallop.

Where galloping has been a problem in the past, the researchers recommend that TxDOT personnel observe the behavior of any newly installed mast arm structure. Make the observation in a 4.5 to 9 m/s (10 to 20 mph) wind, with the wind at the back of the signal head. If the arm tip moves more than ± 200 mm (8 inches), apply damping measures. Use one of these measures:

- ★ Remove the signal head back plate, when feasible, and put the signal head in line with the mast arm (Fig. 7) or at right angles (Fig. 8)
- ★ Change the arm/signal head configuration from an unstable 15° tilt to a more stable one (Fig. 9)
- ★ Install a large damping plate (wing) over the signal head nearest the free end of the mast arm (Fig. 10)

For more information, contact Tim Bradberry, P.E., DES, at (512) 416-2179.

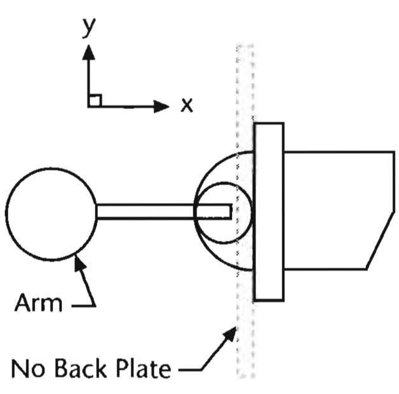


FIG. 7: The configuration least likely to gallop has no back plate and is in line with the mast arm.

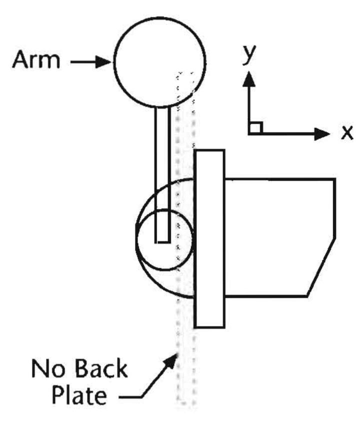


FIG. 8: Without a back plate, this configuration is not prone to galloping.

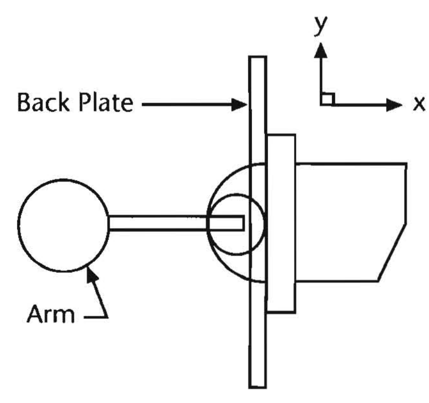


FIG. 9: A more stable configuration for a horizontal signal head with a back plate.

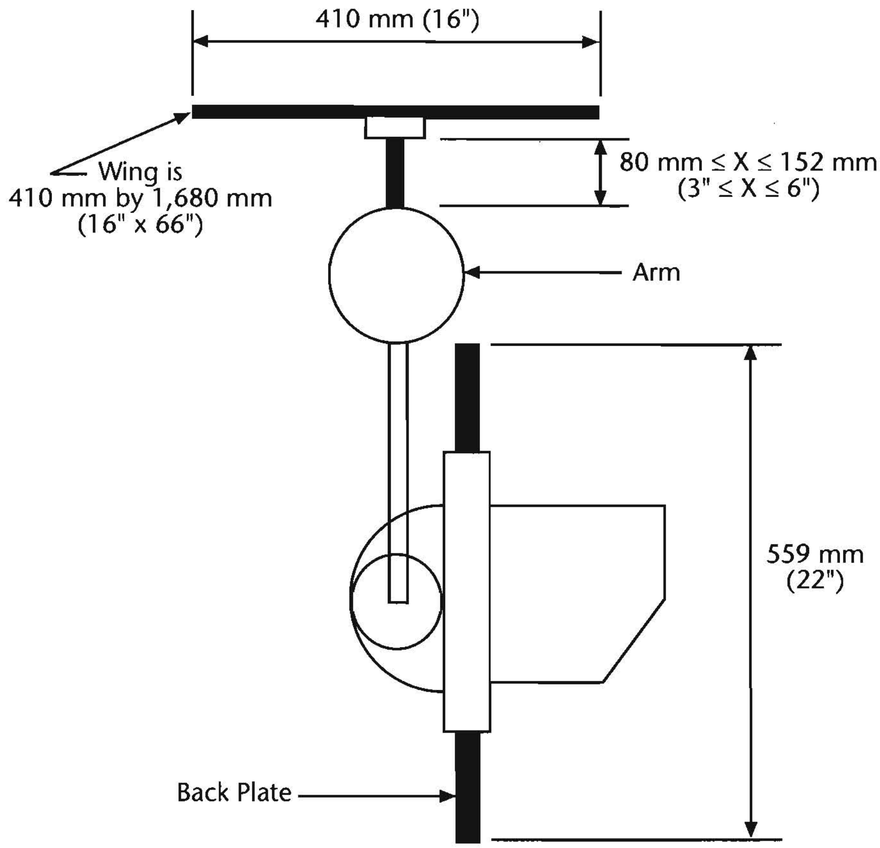


FIG. 10: Mounting arrangement for large damping plate (wing).

tunnel. Research programs have successfully used the Texas Tech tow tank with parachute, automotive, and wind turbine aerodynamics, as well as aerodynamic loadings on solar receivers and traffic signal structures.

In Project 0-1303, researchers used the tow tank to determine the source of the motion sometimes observed in cantilevered mast arm traffic signals. The two candidates were vortex shedding and galloping. The research team developed separate experimental programs to evaluate the significance of each. Flow visualization experiments detected the occurrence of vortex shedding into the wake and identified the shedding frequency. Researchers made steady state aerodynamic lift and drag measurements and applied the Den Hartog [1956] criteria for negative aerodynamic damping to evaluate the potential for galloping. Both the flow visualization and force measurements were performed on full-sized traffic signal heads with and without back plates and with wind directions into the face and into the back of the signal heads.

TECH'S TOW TANK

The Texas Tech tow tank (Fig. 1) is a below-ground, water-filled tank with overall dimensions of 24 m (80 feet) by 4.6 m (15 feet). The water depth is 3.0 m (10 feet). Steel rails mounted above the water on either side of the tank support a motorized towing carriage. This carriage can propel a variety of models through the tank. The carriage also supports computerized motion control and data acquisition systems. Its platform has space for an operator and several observers. Models can be tested at preprogrammed speeds of 0 to 1.5 m/s (0 to 5 ft/s). Acceleration can be up to +0.6 m/s2 (+2 ft/s2). Data acquisition systems include high-speed pressure measurement, load cells for force and moment measurements, and options for video-taped flow visualization both above and below the water surface.

Researchers use the tow tank for any aerodynamic study that might be conducted in a wind tunnel. Air has a 16:1 kinematic viscosity ratio to water. This ratio allows tests of a specific model to be conducted at 1/16 the speed of an equivalent wind tunnel test. The slower speed is an advantage in flow visualization experiments. Dyes, which do not spread over the flow field as rapidly as smoke in a wind tunnel, enhance water-based flow visualization. The tow tank is particularly suited to tests involving transient model velocities that are virtually impossible to duplicate in a wind tunnel.

FIG. 1: General view of tow tank.

CLEARING THE AIR: NEW MODEL RATES PROJECTS FOR AIR QUALITY BENEFITS

by **Gary Lobaugh**
Technical Writer
Information and Technology Exchange Center
Texas Transportation Institute
Texas A&M University

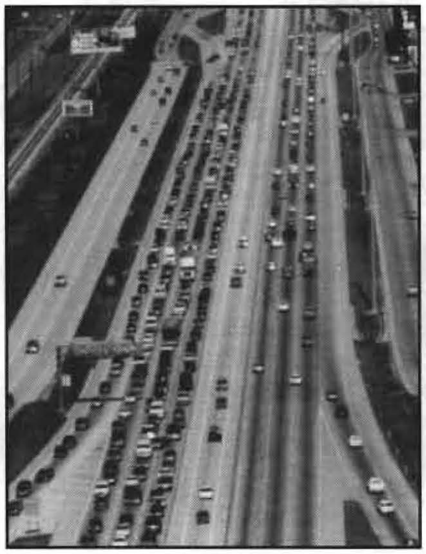
PROBLEM

Under the Clean Air Act Amendments (CAAA) of 1990, metropolitan areas out of compliance — nonattainment areas — must reduce mobile source emissions and improve air quality. Specifically, the nonattainment areas must reduce volatile organic compounds (VOCs), various nitrogen oxides (NOx), carbon monoxide (CO), and particulate matter (PM-10) emissions produced by traffic along urban roadways. VOCs and NOx from vehicles contribute to the formation of ozone. Vehicles also produce much of the CO pollution.

The CAAA sets out a schedule for metropolitan areas to start air quality programs. Areas not meeting this schedule face sanctions, such as the withholding of federal highway funds. To assist metropolitan areas with the implementation of improvement projects, the Intermodal Surface Transportation Efficiency Act of 1991 outlined a Congestion Mitigation/Air Quality (CM/AQ) program.

The CM/AQ program provides an avenue for nonattainment areas to allocate funding to transportation projects, innovative strategies, and new technologies that reduce mobile source emissions. However, funding through CM/AQ requires that metropolitan areas document emission benefits for proposed projects.

To do so, transportation planners need a sound analytical method to evaluate proposed projects. A variety of analysis programs exist. However, no single program combined the flexibility and the update capabilities that the Texas Department of Transportation (TxDOT) wanted to evaluate projects in El Paso, Houston, Dallas/Fort Worth, and Beaumont/Port Arthur. TxDOT contracted with Texas Transportation Institute (TTI) to develop an accurate, flexible software package that could be updated and adjusted.



What improvements will best reduce mobile source emissions?

RESEARCH SOLUTION

Transportation professionals have long recognized the role of traffic congestion in declining air quality: slower travel speeds resulting from congestion severely affect vehicle fuel efficiency, causing increased pollution. Research Project TTI 0-1358, ***Analysis of Congestion Management and Air Quality Transportation Improvement Projects,*** enhanced an evaluation model developed by JHK & Associates. JHK developed the model for the Denver Regional Council of Governments [Ref. 1]. The new model, the TTI CM/AQ Evaluation Model, assists in the decision-making process for allocating funding for projects in Texas' nonattainment areas (Fig. 1).

"In working with the metropolitan organizations, we saw the need for an evaluation tool more applicable to local jurisdictions in Texas," says Burt Clifton, P.E., FTW, TxDOT's project director for 0-1358. "The model developed by TTI addresses the needs of these organizations and TxDOT in evaluating projects and demonstrating their benefits."

What distinguishes this model from other analytical tools is the program's ability to apply the U.S. Environmental Protection Agency's (EPA) emission factor models. The EPA models develop separate emission estimates for each pollutant and compare these estimates among different transportation improvement projects [Ref. 2].

HOW IT WORKS

The TTI CM/AQ Evaluation Model evaluates 59 different CM/AQ strategies for four pollutants, CO, VOC, NOx, and PM-10. The model evaluates projects based on an average 24-hour day, separating the analysis into peak and off-peak periods where the peak period represents the combined AM and PM peaks.

The menu-driven program guides users efficiently through the model so they can quickly and effectively evaluate and compare results of different projects (Fig. 2). Baseline assumptions included in the model ensure that comparisons of different travel modes and project benefits are consistent. Projects run through five analytical modules: eligibility, travel impacts, emissions, cost-effectiveness, and criteria weighting. This analysis produces a rating for each project. Supplementing the rating are absolute and relative changes in travel and emission criteria that will result from implementing a project [Ref. 1].

Project Eligibility Module

Projects must be eligible for CM/AQ funding under current federal law and guidelines. A Federal Highway Administration (FHWA) memo-

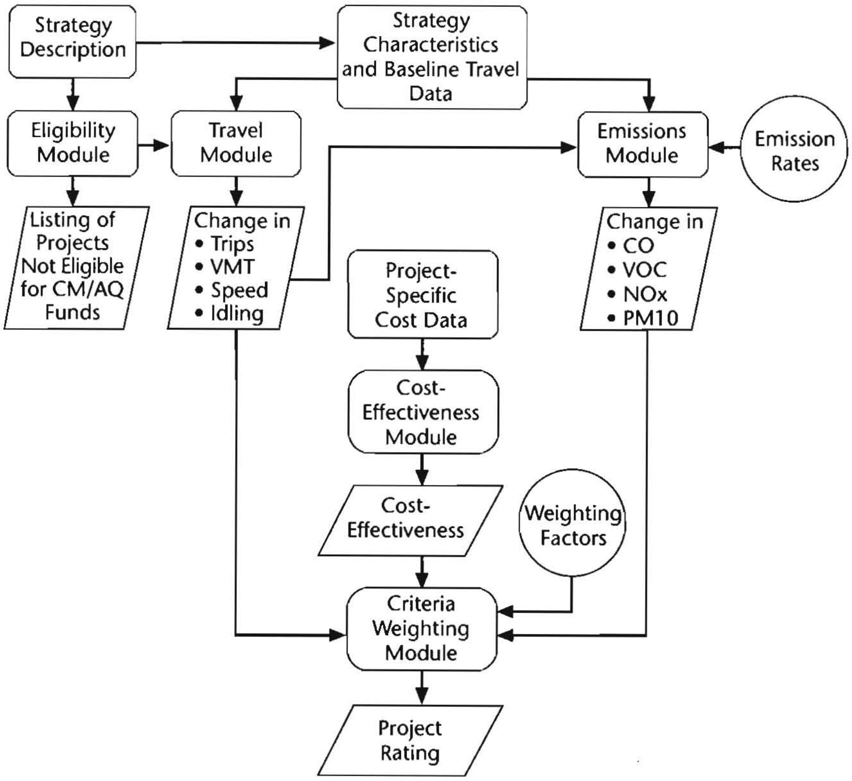


FIG. 1: TTI CM/AQ Evaluation Model structure [Ref. 1].

Initial Setup	Input Project Data	Data I/O
Retrieve Data Save Data Retrieve Baseline Only Save Baseline Only Initialize Data Files	Eligibility Baseline Data Review Projects ├ Eligible Projects └ Ineligible Projects	Travel Data Emission Data Cost-Effectiveness Data Edit Emission Rates ├ Fugitive Dust Rates ├ PM10 └ Emission Rates Baseline Defaults
Run	**Reports**	**Exit**
Travel Impact & Emission Only All Modules	Baseline Data Summary Model Results User Input Data Ineligible Projects	Exit to Paradox Exit to DOS

FIG. 2: Overview of the TTI CM/AQ Evaluation Model menu system [Ref. 1].

randum dated 13 July 1995, outlines the eligibility criteria. The project must be a part of a Transportation Improvement Program (TIP) that meets the CAAA requirements. For example, eligible projects could include: ramp metering, traffic signal timing and coordination improvements, trip reduction plans, or alternative fuel incentive programs. A project that would otherwise be eligible but is not incorporated into an accepted regional or state TIP cannot receive CM/AQ funding.

Users enter descriptions of projects. The module determines eligibility for CM/AQ funding. Eligible projects then can go through the rest of the evaluation model. The module generates a list of ineligible projects, also. Users will probably run an entire set of proposed projects through the Eligibility Module before running the other modules.

Travel Impact Module

This module determines the effect of each project on four key transportation characteristics: vehicle trips, vehicle miles traveled (VMT), average travel speed, and vehicle idling time. Average travel speed refers to total travel time that includes delays and idling, not running speed. This analysis is necessary because travel behavior is critical to the emissions and cost-effectiveness modules.

The module considers a number of variables. These variables consist of:

★ baseline travel characteristics (e.g., the number of commuter trips)

★ strategy-defining parameters (e.g., the percentage of employees receiving a transit pass subsidy)

★ assumptions (e.g., elasticity of transit use with respect to cost) [Ref. 1]

Potentially, the module could require users to enter numerous values. To streamline this process and to ensure consistency throughout evaluation of different projects, the user enters data on a strategy-by-strategy basis. Since some baseline values apply to more than one strategy, the user enters the value only once. It then appears in the data entry screens for later projects.

To minimize the data entry effort, the module includes defaults based on the Denver region and national averages. Users must customize data for their region, and, when needed, override default values with specific values.

This analysis shows changes in vehicle trips, VMT, speed, and idling time in both absolute terms and as a percentage change from baseline values for each project. These changes, reflected in both peak and off-peak values, become data for the Emissions Module.

Emissions Module

The Emissions Module quantifies the effect each CM/AQ project will have on emissions, applying the EPA emission rate models to the Travel Impact Module results. The user supplies some information for specific projects and can override default values. First, the module estimates the baseline level of emissions in kilograms per day (kg/day) by pollutant type. This baseline is compared to the estimated change in emissions that will result after a project is built. This calculation yields the magnitude of the change and determines whether there is an increase or decrease in emissions. The module estimates CO, VOC, NOx, and PM-10 for every project, unless the project will have no impact on a specific emission type [Ref. 2].

Emission changes derived here become data for the final two modules.

Cost-Effectiveness Module

While the Travel Impact and Emissions Modules indicate the effectiveness of the project, these modules do not distinguish the difference in cost between projects. Two projects can have relatively equal effectiveness but vary greatly in their cost. This module calculates the cost-effectiveness of the reduced pollutants by cost per kilogram.

To determine cost-effectiveness, the module divides the total cost of the project by the emission reduction for each pollutant. The module adds the following daily expenses in developing the total cost of a project.

★ **Labor** — The total amount spent on labor per day for a project. This total includes both employee benefits and program administration costs.

★ **Capital** — The cost of facilities and equipment, such as vehicles bought and bicycle storage lockers installed, amortized over the expected life of the facilities and equipment.

★ **Direct Operational** — The cost of performing any operational tasks required for the project. The cost of fuel for additional bus miles is an example.

★ **Overhead** — The overhead cost of the project. For example, extending hours of operation for transit service may result in central facilities remaining open longer, resulting in increased energy usage for lighting [Ref. 1].

The module then subtracts expected daily revenue realized as a result of implementing the project from the total daily expenses to obtain the total cost of the project. It then calculates the cost-effectiveness by dividing the total project cost by the emission reduction separately for each pollutant. Where emissions increase, the module will not perform these calculations because the project is not effective. The results of these calculations become data for the Criteria Weighting Module.

The CM/AQ model does not combine all four pollutants because each represents unique issues. Any attempt to combine their reductions in an overall cost-effectiveness equation would lead to an assumption that the pollutant benefits are additive. Also, the relative importance of each pollutant may change over time, making it difficult to reflect this change in a combined cost-effectiveness calculation [Ref. 1].

Criteria Weighting Module

This module develops a rating of overall effectiveness for each project. The rating is the basis for ranking and comparing all the projects to each other. Each module result receives a value, or weighting factor,

TABLE 1: CRITERIA WEIGHTING MODULE FACTORS [REF. 1]

Criteria/Components	Intermediate Factors	Weighting Factors
Travel Impacts		**30**
Percent VMT Reduction	35	
Percent Speed Increase	40	
Percent Idling Reduction	25	
Emissions Impacts		**30**
Percent CO Reduction	20	
Percent VOC Reduction	20	
Percent NOx Reduction	20	
Percent PM10 Reduction	10	
CO Hot Spot/Hot Grid	20	
PM10 Hot Spot/Hot Grid	10	
Cost-Effectiveness		**30**
CO cost per kg reduced	30	
VOC cost per kg reduced	20	
NOx cost per kg reduced	30	
PM10 cost per kg reduced	10	
Early Project Effectiveness		**10**

based on criteria important in the allocation of CM/AQ funds (Table 1).

The weighted results of the Travel Impact Module, the Emissions Module, and the Cost-Effectiveness Module are data for this module. In addition, the module considers early project effectiveness in the rating procedure. A project that can improve emission levels in less than three years receives a positive early effectiveness value. The weighting factors assigned to these modules are defaults, but users can modify and update these defaults as region priorities change [Ref. 1].

Project ratings developed in this module are the result of the evaluation model. The model develops a separate rating for each project based on the results of each module, not on a comparison between projects. Planners can then review the project ratings and select priority projects for construction.

IMPLEMENTATION

The model meets the current needs and priorities of nonattainment regions. It provides them a way to defend CM/AQ project selection. It supports funding requests to the FHWA. The model also allows for future updates if needs and priorities change over time. An added benefit of widespread implementation: More people using the model will provide more data to refine default values.

"The TTI CM/AQ Evaluation Model provides us with a quick and effective methodology to evaluate a wide range of projects on an equal basis ...."

As part of the contract, TTI created training materials and conducted workshops to educate planners, engineers, and others about the model [Ref. 1]. Workshop topics included an overview of the CM/AQ program, introduction to the TTI CM/AQ Evaluation Model, and discussion of data requirements and potential data sources. Instruction focused on the basic commands and menu system in the model. Participants learned how to edit the model's tables. They also ran fictional projects through the analysis.

"The TTI CM/AQ Evaluation Model provides us with a quick and effective methodology to evaluate a wide range of projects on an equal basis," says Mr. Clifton. "Additionally, its flexibility and ease of use allows for applications in different areas across Texas, as well as throughout the country."

REFERENCES

1. JHK & Associates and Texas Transportation Institute. "TTI CM/AQ Evaluation Model User's Guide and Workshop Training Material," ***Analysis of Congestion Management and Air Quality Transportation Improvement Projects,*** TTI Research Report 1358-1. College Station, Texas: Texas Transportation Institute, April 1995.
2. Crawford, Jason A. Interview with author, 16 August 1996.

MICROSURFACING: CORRECT APPLICATION WILL EFFECTIVELY "SMOOTH THE WAY"

by **Kelly West**
Associate Research Editor
Information and Technology Exchange Center
Texas Transportation Institute
Texas A&M University

BACKGROUND

Microsurfacing is a mixture of emulsified, polymer-modified asphalt, aggregate, mineral filler, water, and additives. Typically, transportation agencies use it to:

- ★ protect pavement from weathering
- ★ seal high traffic volume roadways
- ★ improve skid resistance
- ★ repair some types of rutting

It was first developed and used in Europe in the 1970s. Kansas began using it in 1980 [Ref. 1]. Since then several states, including Texas, have successfully incorporated microsurfacing into their maintenance and surface treatment programs. Although the Texas Department of Transportation (TxDOT), like other states, has a special specification for working with microsurfacing, many people still consider it a "new" maintenance technique.

PROBLEM

Microsurfacing is a fast repair method. It can be (and has been) used successfully on high-volume roadways where quick repair is needed. However, some jobs have had problems. These problems often stem from scattered or incomplete information. Many TxDOT personnel are unfamiliar with the details of proper use. Other pitfalls include lack of experienced contractors and/or lack of quality aggregate.

National mixture design test procedures and standards are still being developed. Specifications prepared by the International Slurry Surfacing Association (ISSA) and by TxDOT haven't been fully tested. In the meantime, some lingering questions needed answers:

★ When should TxDOT use microsurfacing?

★ Are current specifications and mixture design procedures exactly what they need to be?

★ What potential problems should inspectors look for on a job?

RESEARCH RESULTS

To answer these questions, TxDOT and the Federal Highway Administration (FHWA) sponsored Research Project 0-1289, ***Use of Micro-Surfacing in Highway Pavements.*** The Texas Transportation Institute (TTI) conducted it. According to Roger Smith, the TTI researcher in charge of the project, the key objectives were to:

★ create mixture design procedures and tests

★ verify the TxDOT specification

★ provide the department with guidelines for use and quality assurance

"We met our goals through extensive laboratory and field testing over a period of two years," says Smith. "The draft procedure, specifications, and guidelines were also based on evaluation of the ISSA materials and on feedback from TxDOT staff and contractors present at the field trials."

During the first year of the project, researchers worked with construction projects underway at Hearne, Rockwall, Waco, Brownwood, and Brownfield, Texas, to determine design requirements and mixture performance. Later, the number of test sites expanded, involving more than ten sites throughout the life of the project. The full report (TTI Research Report 1289-2F) describes lab and field tests and lists evaluation results. Over the last year and a half, TTI researchers have worked with the TxDOT Materials and Tests Division to refine and to fully implement new test procedures, specifications, and guidelines.

When to Use Microsurfacing

Research confirmed that microsurfacing is effective for:

★ restoring skid-resistance

★ providing a uniform road cross section

★ repairing the effects of weathering

The treatment will generally last from 5 to 7 years if the pavement is in the appropriate condition. "However, if the pavement is not structurally sound, or it's showing significant cracking," says Smith, "microsurfacing is not the best choice."

Microsurfacing will **not** repair extensive cracking, especially alligator cracking. The cracks will quickly reappear through the treatment (Fig. 1). Seal even minor cracking before applying microsurfacing. For rut filling, microsurfacing works best when ruts are flat and not sharp or showing dual wheel marks (Fig. 2). When ruts contain upward heaves or alligator cracking, microsurfacing will not provide a long-lasting solution [Ref. 2].

Problem Prevention

Researchers identified areas where lack of quality control and lack of careful application procedures can cause serious problems. For instance, when the finished surface shows scratch and drag marks, tears, or other irregularities, inspectors should know that the contractor is not providing the desired surface characteristics. The research team identified key causes of this problem:

★ improper strike-off equipment

★ improper application rates

★ lack of training for crews

It is particularly important to prevent buildup of hardened mixture in the spreader box because as it dries, it falls into the mixture and causes drag marks. When this occurs on a regular basis, it usually means that not enough special additive is being used in the mixture, or that there is a problem with the formulation of the emulsified asphalt cement. Excessive drags and scratches could also result if the spreader box is not cleaned between each use and each time the application equipment stops. Trying to apply the microsurfacing thinner than about 1.5 times the nominal aggregate size will also cause excessive drag marks.

Another problem area is joints. Inspectors should watch closely for uneven, nonuniform joints and edges. For both longitudinal and transverse joints, inspectors should not permit excessive buildup, uncovered areas, or an unsightly appearance. Figures 3 and 4 show bad longitudinal and transverse joints. Figure 5 shows a bad edge. Existing edge markings, string lines, and previously placed microsurfacing should be used as controls.

Delamination and other types of postconstruction deterioration can be tied to several different errors. Veg-

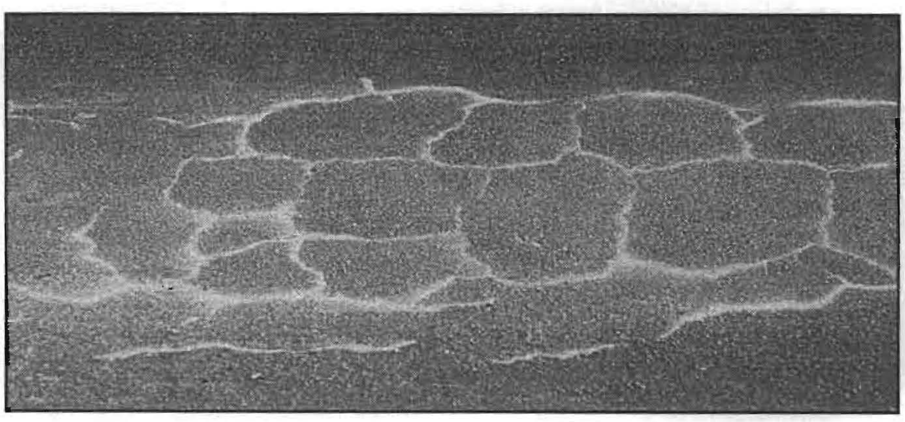


FIG. 1: Alligator cracking is **not** *a candidate for microsurfacing.*

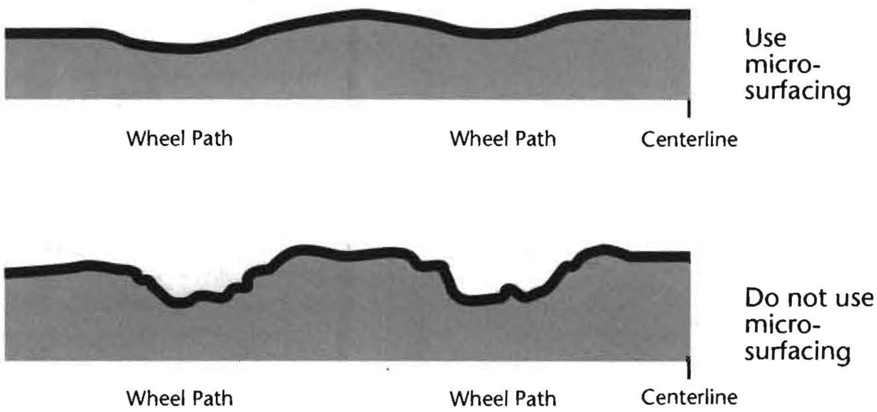


FIG. 2: A comparison of rut types.

etation, animal carcasses, loose aggregate, soil, petroleum, and excessive water on the existing surface may reduce or prevent bonding between the microsurfacing and the existing pavement surface. Also, weather that is extremely hot and humid or weather that is very cool and moist can cause problems. If it is too cool, the emulsion will not break or cure quickly enough to allow traffic on the mixture in the expected time. If it rains on the mixture before the emulsion breaks, severe damage can result. Hot and/or humid weather can cause the tires of stopped or slow-moving traffic to pull the microsurfacing loose [Ref. 2].

"All of these potential problems are easily prevented or corrected with simple quality control measures," says TxDOT project director Maghsoud Tahmoressi, P.E., of the Materials and Tests Division (MAT). "So our implementation efforts for this research have focused on getting the necessary information out to those who are responsible for quality assurance on a job."

IMPLEMENTATION

Specification

At the conclusion of Project 0-1289, researchers delivered a new draft specification using the materials and methods approach. Major changes from previous versions are detailed in TTI Research Report 1289-2F. They include the following key points:

★ The amount of polymer in the residual asphalt cement can be determined by using Texas Test Method TEX-533-C or by using the new gel permeation chromatography procedure described in Appendix C of 1289-2F.

★ Hveem stability is no longer required.

★ Asphalt content should be determined using the nuclear asphalt content gauge. (The asphalt content of polymer-modified asphalt cements mixtures is difficult to determine accurately using vacuum or centrifuge devices.)

★ Aggregates from the actual stockpiles for the job should be used for acceptance and evaluation, since there is no extraction with the nuclear asphalt content gauge.

★ The mixture design requirements have been modified to match the draft procedure found in Appendix A of 1289-2F.

★ A section on workmanship has been added to describe the properties expected in the finished surface.

FIG. 3: A bad longitudinal joint. Joints should be straight and even.

FIG. 4: A bad transverse joint. Note the irregular-looking surface.

FIG. 5: A bad edge. Like longitudinal joints, edgelines should be straight.

The TxDOT specification committee has not yet approved the new special specification.

Guidelines

Originally, appendices of the main research report provided TxDOT with draft use and quality assurance guidelines for microsurfacing and a draft field observation checklist. In a joint effort to implement this research fully, TTI's Information and Technology Exchange Center worked with Associate Research Engineer Roger Smith and TxDOT's Maghsoud Tahmoressi to create a separate field guide for the districts. They also revised the field checklist for user friendliness. The booklet has two sections: use and quality assurance. TxDOT inspectors, engineers, and crew members can all consult the guidelines as a companion to the specification. Tahmoressi says that it's an excellent source of information for people who are experienced with microsurfacing operations, as well as for people who are not. TxDOT personnel can get a copy of the 0-1289 field guide, ***Micro-Surfacing: Guidelines for Use and Quality Assurance,*** by contacting Dana Herring, Research and Technology Transfer Librarian, at (512) 465-7644.

REFERENCES

1. Raza, Hassan, P.E. ***Surface Rehabilitation Techniques: State of the Practice Design, Construction, and Performance of Microsurfacing.*** Publication No. FHWA-SA-94-051. Washington, D. C.: Federal Highway Administration, June 1994.

2. Smith, Roger E., et al. Use of ***Micro-Surfacing in Highway Pavements.*** Research Report 1289-2F. College Station: Texas Transportation Institute, November 1994.

NEW WIND LOAD SPECS YIELD MORE REALISTIC ANSWERS AND POTENTIAL COST SAVINGS

from Research Report 1303-1F,
Wind Load Effects on Signs, Luminaires, and Traffic Structures,
by **James R. McDonald,**
Kishor C. Mehta, Walter W. Oler,
Wind Engineering Research Center
Texas Tech University
and **Narendra Pulipaka,**
Vertex Communications Corp., Kilgore, TX
excerpted by **Kathleen M. Jones**
Information Specialist II
Research and Technology Transfer Office
Texas Department of Transportation

BACKGROUND

Twenty-year-old data and outdated technology are the basis for the current wind load provisions. In the last two decades, wind loading research has developed and matured. Wind speed data from additional recording stations can provide better design wind speed values. New technologies have made possible a gust response factor. This factor is an improvement over the current American Association of State Highway and Transportation Officials (AASHTO) 1985 standard because it accounts for wind gust variations. Use of the wind gust factor gives more consistent wind load response data for a variety of structures. Clearly, the AASHTO wind load provisions needed to be brought up to date. The Texas Department of Transportation (TxDOT) contracted with Texas Tech University's Wind Engineering Research Center to revise the wind load section of the TxDOT design standard for highway signs, light poles, and traffic signal structures. An ongoing NCHRP project will make similar revisions to the AASHTO standard. This article will highlight significant changes proposed by Research Project TECH 0-1303, ***Wind Load Effects on Signs, Luminaires, and Traffic Structures.*** Implementation of the project's recommendations will be decided following the revision of the AASHTO standard.

WIND SPEED HAZARD MAP

Using additional wind speed records from the last 20 years and data from 32 recording stations, the 0-1303 research team developed a new wind speed hazard map (Fig. 1) for the state of Texas. The previous map was based on data from only nine stations. The new map shows wind speed expressed as the maximum sustained (fastest-mile) winds at 10 m (33 feet) above ground in flat, open terrain. The mean recurrence interval (MRI) for these fastest winds is 50 years. Expressing the wind speed this way keeps the reference wind speed consistent with the current (1985) AASHTO specification. The American Society of Civil Engineers standard, *"Minimum Design Loads for Buildings and Other Structures"* (ASCE 7-95), has a new wind map expressed in 3-second gust speeds. It cannot be compared to the new Texas wind speed because of the different averaging time of wind speed.

The map defines four distinct wind speed regions. The wind speed regions are indicated by county, rather than by contour lines. The research team decided that plotting by counties was easier for people to interpret. In areas where records or experience shows that local wind speeds are generally higher than the value shown on the new map, designers should adjust the basic wind speeds to account for local winds. Base such adjustments on sound meteorological advice and standardize the values for height and exposure.

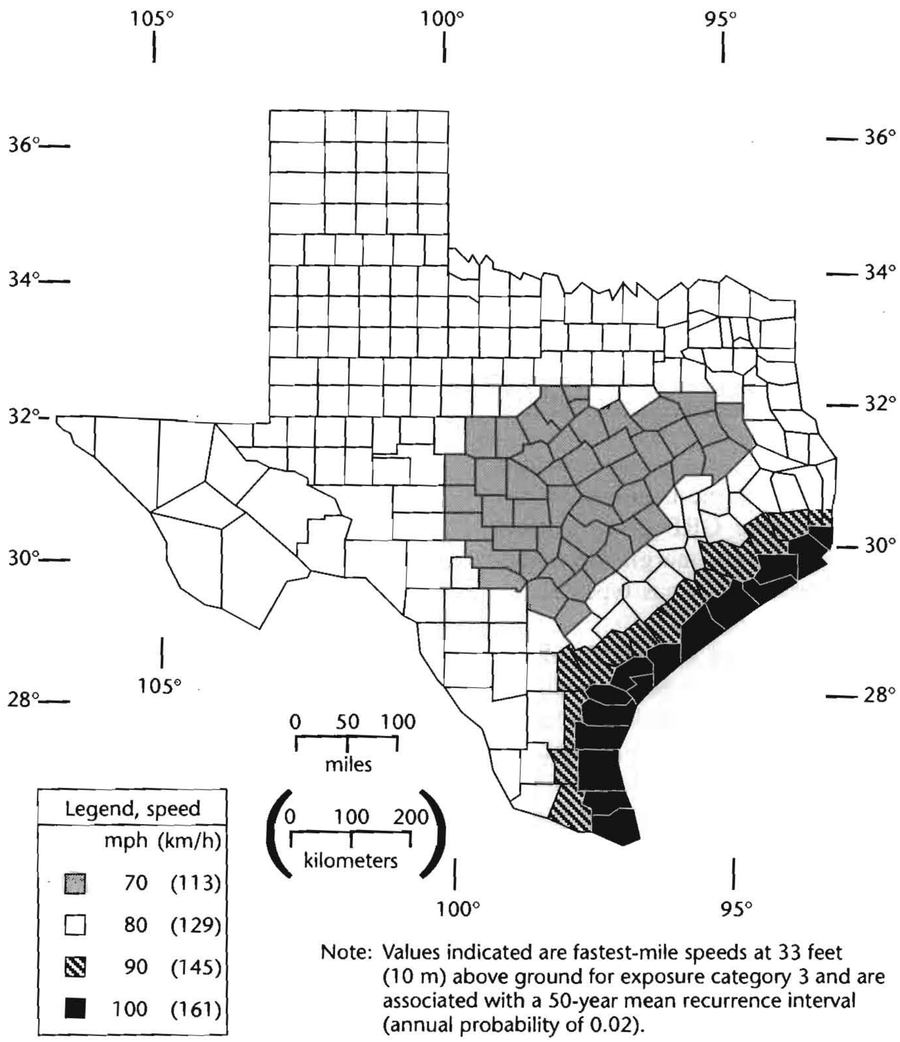


FIG. 1: Recommended basic 50-year wind speeds for counties in Texas.

WIND LOAD PARAMETERS

The proposed revisions affect three of the existing parameters — the Importance Factor, Exposure Categories, and the Gust Factor.

Importance Factor

The importance factor is based on the expected life of the structure, the probability of wind speed occurrence (mean recurrence interval), and the importance of the structure. For various types of structures, the new standard provides recommended MRI values of from 5 to 100 years (Tables 1 and 2). The values used in the importance factor were developed from the wind speed hazard analysis done in Project 0-1303. Note that there are two sets of importance values: one for hurricane, and the other for nonhurricane, winds.

Exposure Categories

At ground level to about 91 m (330 feet), ground roughness reduces wind speed through friction. Higher up, the influence of ground roughness on wind speed diminishes. Above 213 m (700 feet), ground roughness does not affect wind speed. The proposed wind load specification adds a new exposure category. This category, category 2, represents outskirts of towns, countryside with scattered buildings, and areas with clumps of trees or bushes. It falls between ASCE 7-88 Exposure Categories B and C. Categories 1, 3, and 4 are equivalent to ASCE 7-88 Exposure Categories B, C, and D, respectively.

Exposure category 1 represents normal urban and suburban development with few open lots. Solid, heavy forests would also be in this category. Flat, open terrain with short grass qualifies as category 3. Exposure category 4 is used only for open water or arid, flat terrain with little ground cover. The researchers developed exposure and height factors for all four categories. These values are given in the new provi-

TABLE 1: MEAN RECURRENCE INTERVALS FOR VARIOUS STRUCTURES

Structure	MRI (Years)
Luminaire Support > 15.24 m (50 feet)	50
Structure Supporting Sign(s) Over Roadway	50
Luminaire Support < 15.24 m (50 feet)	25
Traffic Signal Support Structures	25
Structure Supporting Sign(s) Not Over Roadway	25
Traffic Signs (Breakaway)	10

TABLE 2: IMPORTANCE FACTOR, I

Mean Recurrence Interval (Years)	I	I*
5	0.82	0.82
10	0.88	0.88
25	0.95	1.00
50	1.00	1.05
100	1.07	1.11

* For hurricane zones where basic wind speed is 145 km/h (90 mph) or greater and within 161 km (100 miles) of oceanline.

TABLE 3: CONDITIONS OF EXAMPLE PROBLEMS					
Structure	Location	County	Basic Wind Speed km/h (mph)	Exposure Category	Distance Coastline km/h (mph)
Traffic Signal Structure	San Antonio	Bexar	113 (70)	1	>161 (>100)
Traffic Signal Structure	San Antonio	Bexar	113 (70)	2	>161 (>100)
Overhead Sign Bridge	Lubbock	Lubbock	129 (80)	3	>161 (>100)
Breakaway Roadside Sign	Woodville	Tyler	145 (90)	2	133 (83)
High Mast Luminaire	Corpus Christi	Nueces	161 (100)	4	0 (0)
Roadway Illumination Assembly	Corpus Christi	Nueces	161 (100)	4	0 (0)

sion. Engineering judgment is essential in selecting the appropriate exposure category for areas of mixed terrain. The choice of a higher category yields a more conservative design.

Gust Response Factor

The Project 0-1303 approach to defining gust response factor (GRF) is different from the approach used before in the AASHTO standard. An AASHTO gust factor of 1.3 is, in effect, equal to a GRF of 1.69 regardless of ground roughness or structure size.

The gust response factor depends mainly on the gustiness of the wind and a structure's size. It also accounts for the effects of ground roughness and height of a structure above the ground. Gusts are a localized occurrence. Small structures can be completely enveloped by them. Therefore, small structures have larger gust response factors than larger structures. A structure responds to wind as a unit, so engineers will select a single gust response factor for a given structure, using the maximum height of the structure. The GRF gives a more consistent safety margin for structures located in various types of terrain.

The GRF does not include allowances for crosswind deflections, vortex shedding, galloping or flutter instabilities, or for increase of dynamic resonance loading in flexible buildings.

EXAMPLES

In Report 1303-1F, the researchers determine the wind loads of five typical TxDOT structures using the proposed provisions and using the current AASHTO (1985) ones. The types and conditions of the structures used in the examples are given in Table 3.

The ratio of wind loads using the proposed revisions to current provisions varies from 0.36 to 1.14. The average of the five structures is 0.80. The revised provisions provide wind loads that are more consistent with the terrain and the types of structure.

SUMMARY

The Project 0-1303 proposed revisions to standard design specifications incorporate new technology in defining appropriate wind loads. One of the results is a new wind speed map for Texas. The proposed revisions introduce a procedure that uses a gust response factor, accounts for different terrain, and makes use of the new wind speed map. Not only are the wind loads more realistic, but, in some cases, the revised standard will specify smaller loads than the current specification. In these cases, money can be saved in structure fabrication without sacrificing the safety or reliability of the structure.

For more information, contact Tim Bradberry, P.E., DES, at (512) 416-2179.

UPDATE ON TXDOT METRICATION EFFORTS

by **Tracey Friggle, P.E.**
Construction and Maintenance Division
Texas Department of Transportation

HISTORY

In 1988, Congress passed the Omnibus Trade and Competitiveness Act, which declared that the metric system would be the preferred system of weights and measures for U.S. trade and commerce and required each federal agency to convert to the metric system. In 1991, the Federal Highway Administration (FHWA) developed a conversion plan and timetable to lead state DOTs to complete metric conversion by September 30, 1996.

TxDOT began surveying in metric in February of 1994. All projects that were surveyed on or after that date are to be developed in the metric system. Only projects that were surveyed before February of 1994 and that were considered too far along in the development process were allowed exceptions to original FHWA September 1996 deadline.

TxDOT was well underway with the metric conversion when, in November of last year, Congress enacted a National Highway System bill that gave the states relief from the mandate requiring conversion of plans and specifications to metric until September 30, 2000. This four-year extension came too late for TxDOT. Most of TxDOT's metrication effort was complete by the time the NHS bill was enacted into law.

TXDOT METRICATION EFFORT

TxDOT completed metrication of and began distribution of the ***1995 Standard Specifications Book*** in March 1995. Over 15,000 copies have been distributed. The new spec book also includes metric versions of the maintenance specifications.

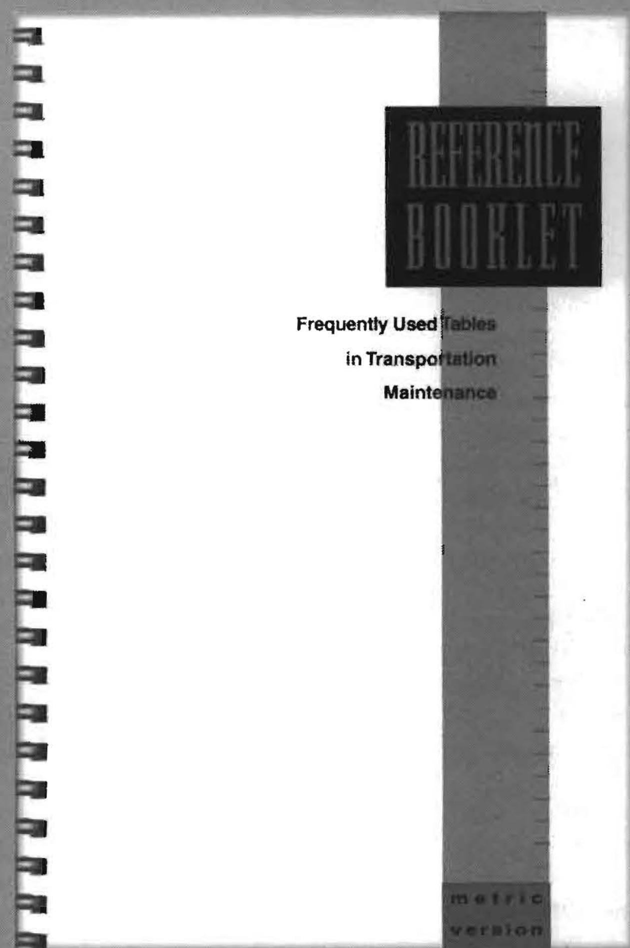
The design and construction standard sheets are nearly all complete in a metric format. The Bridge Section of the Design Division had almost 1,000 standard sheets to convert to metric. Several hundred other design and traffic standards are complete in their new metric format. About 20,000 person-hours were spent on standard conversion.

Testing procedures have been converted to metric. Metric conversion has not required the purchase of any new testing equipment. Most of the newer equipment has the capability of working in either system. Older equipment will be replaced with metric equipment as it wears out.

Many pieces of nonelectronic surveying equipment were replaced or supplemented with metric equipment.

Most of the manuals and computer software used by TxDOT employees for design and construction have been converted and are already in the hands of the district personnel. Recently, TxDOT published a metric version of ***Frenquently Used Tables in Transportation Maintenance*** (formerly, ***Frenquently Used Tables in Highway Maintenance***).

Various training courses have been initiated to train TxDOT employees in the use of the metric system. TxDOT's training program includes courses for surveyors, designers, inspectors, and office personnel. The Texas Engineering Extension Service (TEEX) has adapted several of these courses for Texas municipalities. TxDOT also participated in several workshops with the AGC which helped inform TxDOT contractors, subcontractors, suppliers, and producers about our change to the metric system and how it would affect them.



METRIC TABLES FOR MAINTENANCE

The Reference Booklet of Frequently Used Tables in Transportation Maintenance, Metric Version, was a joint effort by the Construction and Maintenance Division (CMD), the Design Division (DES), the Research and Technology Transfer Office (RTT), and the Texas Transportation Institute (TTI) to update the popular FHWA publication, *Frequently Used Tables in Highway Maintenance.* The Metric Task Force wanted convenient, hard conversions of such elements as the amount of asphalt required to cover specific distances at various application rates. TTI surveyed the districts' maintenance personnel to find out which of the old tables they wanted to have converted and what new information they might need.

The resulting book is in four parts:

★ Metric Areas and Rates of Application

★ Metric Volumes and Weights

★ Metric Conversion Factors

★ Metric Reference Points

The pocket-sized book is wire bound to open flat. It is printed on water-, tear-, and oil-resistant paper to stand up to hard use in the field.

The Reference Booklet of Frequently Used Tables in Transportation Maintenance, Metric Version, is available from the RTT Library. Call Librarian Dana Herring at (512) 465-7644.

LETTING

TxDOT began letting metric projects in October 1995. Since September of last year, TxDOT has let about $156,000,000 in metric projects. In fiscal year 1997, we will let over $252,000,000 in metric projects. This constitutes 15 percent of the 1997 letting budget.

When Congress passed the NHS bill, TxDOT was too far involved in the metric system to consider going back. Time involved for plan preparation from inception to letting is a minimum of two years. To remove the metric plans from the letting schedule and redesign them would mean that all these projects would be a minimum of two years behind schedule. We do not have enough plans on the shelf to replace these metric plans. If we removed metric plans from letting, over $400,000,000 would be missing from our letting schedule over the next two years. To delay the letting of these plans would be painful to TxDOT, the contracting community, and especially the road users of Texas.

OTHER STATES

A recent AASHTO survey indicates that most states intend to continue with the metric system regardless of the NHS legislation. Forty-four states indicated that the newest NHS legislation would not delay their conversion to the metric system. Of the states that anticipated a delay, all but three, North Dakota, South Dakota, and Hawaii, indicated their delays were related to completion of manual conversions or other minor internal concerns, not delays in their lettings.

SUMMARY

TxDOT is ready for the metric system. There has been no appreciable increase in the bid prices of the projects that have been let in metric, nor do we expect one. Our contractors are ready, willing, and able to bid and build in metric. Our employees have been trained, or will be trained this year, in the use of the metric system and are adapting well. At this point, a return to the old way of doing things will stall the momentum we have built and delay progress in road construction in Texas. TxDOT is ready for the metric system, and it is our strong recommendation that this effort be continued.

IRF CALLS FOR EU TRUCK CHARGE PROCEEDS TO BE INVESTED IN ENVIRONMENTALLY FRIENDLY ROADS

by **Christian A. Michaud**
Program Officer
International Road Federation
(Geneva Office)

The International Road Federation (IRF), which represents Europe's road builders, says that proposed new European Union (EU) truck charges can be justified only if the revenue from them is re-invested in the European road system, and not siphoned off to general government treasuries.

The IRF has studied the just-announced European Economic Community (EEC) plans to transform the existing method of uniform charges ("Eurovignette") for trucks that use EU roads. Its new proposals call for a sophisticated system of variable charges related to the pollution and the road wear caused by trucks. "In line with our EUROVIA program for the development of advanced motorways in Europe, we fully support the EEC proposals on this issue," says IRF Director General, Wim Westerhuis, "but with one strong proviso."

"The philosophy behind the new proposals is to make truckers pay for the environmental damage and the road infrastructure wear and tear that they cause. We think this is fully justified as long as the revenue generated will be used to correct the deficiencies — including the environmental ones — of European road infrastructure, in order to reduce congestion, pollution and accidents. There is no point in the EU or member states taking these funds simply to remedy their budget problems or to subsidize loss-making rail schemes," says Mr. Westerhuis.

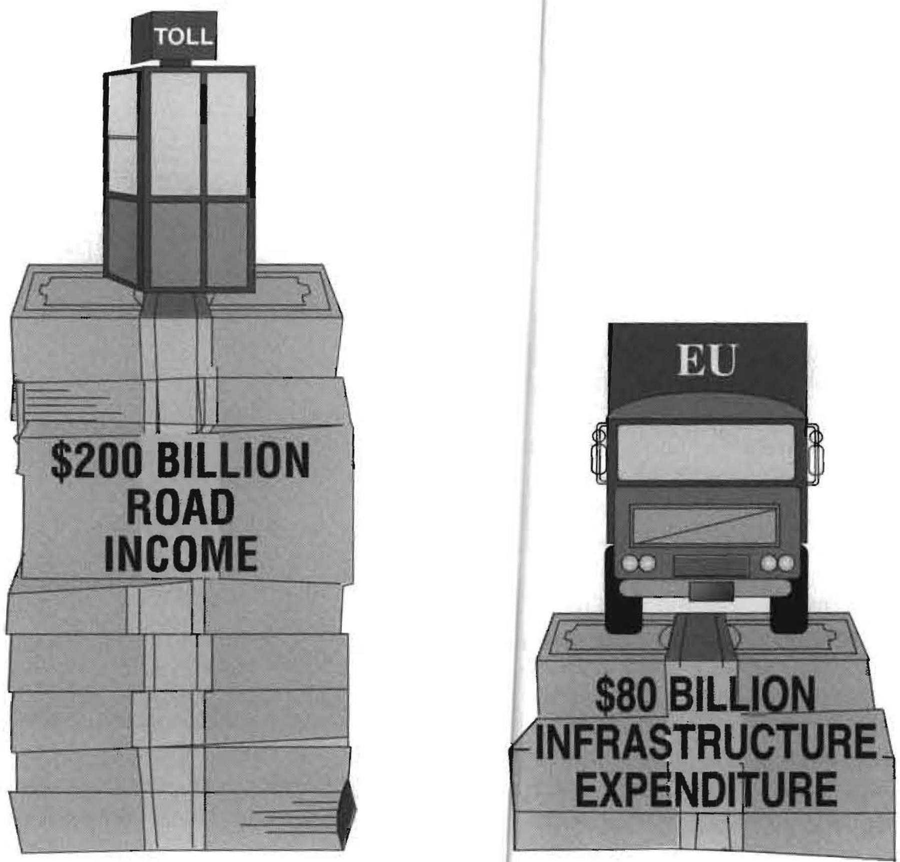
"This is what governments do with the current massive revenues generated by EU road networks. The end result has been severe underinvestment in European road infrastructure improvements and unfair subsidies for railways. IRF studies have shown that through taxes and tolls, every year road users actually pay European governments three times more than what all roads cost to build, operate and maintain. For example, in the 18 most industrialized EU and EFTA countries, 1994 road income was approximately 200 billion ECUs (European Economic Community Units). Yet governments spent only 80 billion ECUs on road infrastructure. In other words, the annual net profit of the European road system is more than 100 billion ECUs per year!"

Under the EEC plan, the existing flat-rate Eurovignette would be replaced by a system of either variable vignettes (staggered according to the weight and exhaust emissions of the heavy goods vehicle category), or increases in the existing taxation on such vehicles; or additional "external-cost-related" tolls. The system would be applied Europewide, and would replace two separate vignettes now operating in Belgium, Denmark, Germany, Luxembourg and Netherlands on the one hand, and in Austria on the other hand. The EC says the new system will reduce harmful exhaust emissions, will decrease congestion on sensitive routes, and will generate large infrastructure cost savings.

"The IRF would be delighted if all of this could be achieved," says Mr. Westerhuis. "But it will only happen if the new revenues generated from these truck charges are specifically earmarked for road investment, otherwise, perennial road problems will simply continue." The IRF is a nonprofit, nonpolitical service organization that promotes better road and transportation systems worldwide. More than 600 companies, governments and associations are IRF members, and help in the application of technology and management practices to produce the maximum economic and social return from road investments.

For more information, contact Christian A. Michaud at 63 rue de Lausanne, CH-1202 Geneva, Switzerland:

- ★ Phone, ++41-22 731 71 50
- ★ Fax, ++41-22 731 71 58
- ★ E-mail, mailto:irf@dial.eunet.ch;
- ★ World Wide Web URL, http://www.eunet.ch/Customers/irf



The IRF recommends that revenue generated be earmarked to reduce pollution, congestion, and accidents.

STATEWIDE SYSTEM FOR PRIORITIZING BRIDGE PROJECTS TO CONTINUE

Ralph K. Banks, P.E.
Design Division
Texas Department of Transportation

Fiscal year 1996 marked a first for the Texas Department of Transportation (TxDOT) — a statewide system for selecting federal-aid bridge program projects. The scoring system, called the Texas Eligible Bridge Selection System (TEBSS), is based on the simple notion of "addressing the worst bridges first." It was developed from research projects CTR 0-439, CTR 7-1911, and CTR 7-1945. The author was involved throughout this research, drafting the initial problem statement and guiding the studies as project director.

The new process replaces the practice of allotting money to each TxDOT district and allowing the district staff, in coordination with local governments as appropriate, to make project selections. The main problem with using allotments was that bridges in serious or critical condition might not be replaced or repaired in a timely and coordinated manner. For example, District A might be replacing bridges that were not as bad as some bridges on the same route in adjacent District B. This situation made TxDOT liable if a bridge in District B should collapse that was known to be in worse condition than those scheduled for replacement in District A. TxDOT feels heavily the responsibility to avoid any such collapses.

TEBSS helps optimize the use of TxDOT personnel and resources. Thus, federal bridge funds are used more efficiently, assuring that deficient bridges will not remain in service too long. The final tally of contracted bridge projects and the dollars represented after this first year is 58 on-system projects at a cost of $73 million and 78 off-system projects at a cost of $19 million. Since the total dollar amount of these projects represents almost all of the federal bridge apportionments for FY 1996, the process appears to have been successful. Consequently, TxDOT will continue its use.

For more information on the implementation of TEBSS, contact Ralph K. Banks, P.E., DES, at (512) 416-2173. For copies of the background research reports, contact Dana Herring, Research and Technology Transfer Librarian, at (512) 465-7644.

THE ROAD KNOWS:
AVI IMPLEMENTATION SHOWS SUCCESS

by **Ryan Sanders**
Technical Writer
Texas Transportation Institute
Texas A&M University

Some Harris County toll roads are using AVI technology to collect tolls automatically, charging them to the motorists' accounts.

INTRODUCTION

Imagine that you had a crystal ball that would tell you where all the traffic pitfalls were located so you could minimize your travel time each day. If you did, you would change your route, time, or mode of travel to avoid those delays, wouldn't you?

Texas Transportation Institute (TTI) researchers are currently working on a system that, like a crystal ball, reveals "unknown" travel information — those elusive traffic reports.

Real-time traffic monitoring systems deliver up-to-the-minute traffic information to traffic managers and motorists. They rely, in part, on automatic vehicle identification (AVI) technology. Texas Department of Transportation (TxDOT) project, ***Development and Implementation of an Automatic Vehicle Identification (AVI) System,*** TTI 7-1958, focuses on refining this technology and on progressing toward a complete "smart highway" information system. The testbed for this work is Houston, Texas. The system, now having gone through three phases of operational testing, is well into the implementation stage.

HOW DOES IT WORK?

The real-time traffic information system uses AVI technology to gather information from vehicles equipped with transponder tags. Antennas, placed along designated roadways at intervals of approximately 5 km, send out sonar signals that reflect from transponder tags attached to the windshields of participating vehicles. Computers transmit the reflected signal's modified information over telephone lines to the traffic management center. There, software converts the raw data into real-time speed and travel-time information. The speeds and travel times are then converted to visual maps and tables to enable quick interpretation and response. Once the information reaches area media outlets, motorists can access it through radio or television traffic reports, the Internet, or roadside changeable message signs.

HOW DOES IT HELP?

"The system transmits field data to the traffic management center within one minute of the time it was collected, and the data are accurate to the nearest second," says William McCasland, head of TTI's Houston office and coauthor of the project's first report (1958-1).

Previous automatic vehicle location systems, such as the one implemented by the San Antonio VIA Metropolitan Transit Authority last year, used roadside signposts to track city buses and ensure timely bus routes. McCasland says these applications for buses, as well as for HOV lane management and for parking lot access, are all possible uses for AVI technology in Houston's future.

Some Harris County toll roads already use AVI technology to collect tolls. Antennas read transponder tags on participating vehicles as they drive through toll booths and automatically charge the toll to that motorist's account.

"Drivers are gaining real reductions in travel delay," McCasland says. "AVI saves time and fuel just from avoiding the slow-down and wait at a toll gate."

Clearly, the AVI system delivers valuable information to traffic authorities and the general public, but it's difficult to pinpoint measurable benefits of AVI, McCasland says, because success really depends on what people do with that information.

Traditionally, for example, travel-time information is collected once or wice a year by repeatedly driving ections of roadway and averaging he times. By contrast, the AVI sys- em provides transportation research- rs and planners with true travel- ime information at all times, every lay of the year. If freeway planners r designers can take that real travel- ime information provided by AVI nd use it for more accurate plan- ing and design functions, that's suc- ess.

VHAT WILL THEY THINK OF VEXT?

To refine the AVI system, TTI's ext step is to target busy freeway nterchanges in Houston — where nost congestion occurs and more in- ormation is needed — and to equip hem with more AVI traffic-monitoring echnology.

Engineers are also looking for vays to make the traffic information nore accessible to motorist — ways o integrate the smart highway data nto smart vehicles. One possible so- ıtion is to develop "smarter" tran- ›onders that provide two-way com- unications with the roadside antennas. ıe first application of that sort is al- ıdy planned for large trucks travel- ; through freeway interchanges h reduced speed limits. The AVI tem will be used to activate a ning device in the driver's com- ment if the truck's speed is too .

'n the past, we've used roadside s to warn drivers about speed ers," McCasland says. "Now, trying to get a little more per- . We'd really like to get the to respond so that we know he ed the information, understood l reacted to it." The hope is ch a device will provide a bet- ·ning system to truck drivers ıg at speeds that are too high ·ailing conditions.

ᴈ next year of the project, re- ·s will investigate other ap- s that provide general traffic ıs for persons with AVI tran- on their vehicles. Future work will also take the system from using telephone communication to direct links provided by fiber-optic cable. Maybe someday all motorists will be able to steer clear of traffic congestion just by looking at a little crystal ball — or computer display — on their dashboard.

To order TTI Research Report 1958-1, contact Dana Herring at (512) 465-7644. For more information on Houston's AVI system, contact Carlton Allen, P.E., HOU, at (713) 881-3285 or William McCasland, TTI, at (409) 845-2515 (E-mail: wmccasland@tamu.edu).

Reprinted with minor editing from TTI's *Researcher* 32(Spring 1996): 8-10.

CLICK ON THIS

Internet users can now access more detailed traffic information using new functions of the Houston Real-Time Traffic Map, developed by Texas Transportation Institute (TTI) and located on the World Wide Web. By clicking specific locations on the map, users can obtain additional information on freeway segments or entire freeways.

In the summer of 1993, during Phases I and II of TxDOT project 7-1958, called *Development and Implementation of an Automatic Vehicle Identification (AVI) System*, TTI Research Associate Dan Hickman developed the program that draws the traffic map image. The map image, called AVIview, was designed to display traffic speed data collected by the system's sensors.

During the fall of 1994, Hickman added a feature that captures the image at time intervals of one minute and saves each real-time image to a file on the web server. By December of that year, the Houston Real-Time Traffic Map was a fully working service on the Internet, displaying color-coded roadway segments: red for 0–19 mph, orange for 20–29, yellow for 30–39, blue for 40–49, and green for 50 and above.

Now, thanks to information more recently saved to the web server, users can click on any roadway segment and access the precise distance of that segment along with its average speed and actual travel time. In addition, users may click below the map on the name of any freeway shown on the map to see a summary of detailed data on the entire freeway.

HOU Real-Time Traffic Map Web site.

This spring, during Phases III and IV of the AVI project, TTI researchers will install sensors along other freeways in Houston. These freeways will be added to the real-time map this summer.

"Although we developed this program specifically for the AVI project, the traffic map has numerous ITS applications in Houston," Hickman says. "In the future we hope to offer added information from other TranStar projects including loop detector data, incident logs, and roadway construction reports."

The Houston Real-Time Traffic Map is located on the Internet: http://herman.tamu.edu/traffic.html

Reprinted with minor editing from TTI's *Researcher* 32(Spring 1996): 9.

INSIDE TQ

BRIDGES

New Wind Load Specs Yield More Realistic Answers and Potential Cost Savings 12

Statewide System for Prioritizing Bridge Projects to Continue 17

COMPUTERS

Clearing the Air: New Model Rates Projects for Air Quality Benefits 6

The Road Knows: AVI Implementation Shows Success 18

CONSTRUCTION

Clearing the Air: New Model Rates Projects for Air Quality Benefits 6

Update on TxDOT Metrication Efforts 14

IRF Calls for EU Truck Charge Proceeds to Be Invested in Environmentally Friendly Roads 16

DESIGN

"Galloping" Signal Arms: A Method to Damp the Motion 1

New Wind Load Specs Yield More Realistic Answers and Potential Cost Savings 12

ENVIRONMENTAL ISSUES

Clearing the Air: New Model Rates Projects for Air Quality Benefits 6

IRF Calls for EU Truck Charge Proceeds to Be Invested in Environmentally Friendly Roads 16

MAINTENANCE

"Galloping" Signal Arms: A Method to Damp the Motion 1

Microsurfacing: Correct Application Will Effectively "Smooth the Way" 9

METRICATION

Update on TxDOT Metrication Efforts 14

TRAFFIC OPERATIONS

Clearing the Air: New Model Rates Projects for Air Quality Benefits 6

The Road Knows: AVI Implementation Shows Success 18

TRANSPORTATION ISSUES

IRF Calls for EU Truck Charge Proceeds to Be Invested in Environmentally Friendly Roads 16

Texas Department of Transportation

RESEARCH MANAGEMENT COMMITTEE MEETING

June 2-6, 1997
La Quinta Conference Center
825 N. Watson Road, Arlington, Tex
Reservations 1 (800) 453-7909
by May 2, 1997 (cut-off date)

June 2 (1:00 pm) — June 3 (5:00 pm)

RMC 4 "Roadway Planning and Design"

RMC 5 "Structures"

RMC 8 "Construction and Maintenance"

June 4 (8:00 am) — June 5 (12:00 pm)

RMC 1 "Management and Policy"

RMC 3 "ROW, Hydraulics, and Environmental Conservation"

RMC 7 "Materials"

June 5 (1:00 pm) — June 6 (5:00 pm)

RMC 2 "Multimodal Operations"

RMC 6 "Pavements"

RMC 9 "Traffic Operations"

Direct any questions to:

Dana Herring, DHERRIN (inside TxDOT
DHERRIN@mailgw.dot.state.tx.us
(512) 465-7644 or
Debbie Hall, DHALL1 (inside TxDOT)
DHALL1@mailgw.dot.state.tx.us
(512) 465-7684
Fax (512) 465-7486

TECHNOLOGY TRANSFER & LIBRARY SERVICES

Manager: Debbie Hall
(512) 465-7684

★

Editor/Tech. Writer: Kathleen Jon
(512) 465-7947

★

Editor/Tech. Writer: Kay Lee
(512) 467-3882

★

Librarian: Dana Herring
(512) 465-7644

Technical Quarterly
c/o Kathleen M. Jones, RTT, TxDOT,
P.O. Box 5080, Austin, TX 78763-5080

twice a year by repeatedly driving sections of roadway and averaging the times. By contrast, the AVI system provides transportation researchers and planners with true travel-time information at all times, every day of the year. If freeway planners or designers can take that real travel-time information provided by AVI and use it for more accurate planning and design functions, that's success.

WHAT WILL THEY THINK OF NEXT?

To refine the AVI system, TTI's next step is to target busy freeway interchanges in Houston — where most congestion occurs and more information is needed — and to equip them with more AVI traffic-monitoring technology.

Engineers are also looking for ways to make the traffic information more accessible to motorist — ways to integrate the smart highway data into smart vehicles. One possible solution is to develop "smarter" transponders that provide two-way communications with the roadside antennas. The first application of that sort is already planned for large trucks traveling through freeway interchanges with reduced speed limits. The AVI system will be used to activate a warning device in the driver's compartment if the truck's speed is too high.

"In the past, we've used roadside signs to warn drivers about speed dangers," McCasland says. "Now, we're trying to get a little more personal. We'd really like to get the driver to respond so that we know he received the information, understood it, and reacted to it." The hope is that such a device will provide a better warning system to truck drivers operating at speeds that are too high for prevailing conditions.

In the next year of the project, researchers will investigate other applications that provide general traffic conditions for persons with AVI transponders on their vehicles. Future work will also take the system from using telephone communication to direct links provided by fiber-optic cable. Maybe someday all motorists will be able to steer clear of traffic congestion just by looking at a little crystal ball — or computer display — on their dashboard.

To order TTI Research Report 1958-1, contact Dana Herring at (512) 465-7644. For more information on Houston's AVI system, contact Carlton Allen, P.E., HOU, at (713) 881-3285 or William McCasland, TTI, at (409) 845-2515 (E-mail: wmccasland@tamu.edu).

Reprinted with minor editing from TTI's *Researcher* 32(Spring 1996): 8-10.

CLICK ON THIS

Internet users can now access more detailed traffic information using new functions of the Houston Real-Time Traffic Map, developed by Texas Transportation Institute (TTI) and located on the World Wide Web. By clicking specific locations on the map, users can obtain additional information on freeway segments or entire freeways.

In the summer of 1993, during Phases I and II of TxDOT project 7-1958, called *Development and Implementation of an Automatic Vehicle Identification (AVI) System,* TTI Research Associate Dan Hickman developed the program that draws the traffic map image. The map image, called AVIview, was designed to display traffic speed data collected by the system's sensors.

During the fall of 1994, Hickman added a feature that captures the image at time intervals of one minute and saves each real-time image to a file on the web server. By December of that year, the Houston Real-Time Traffic Map was a fully working service on the Internet, displaying color-coded roadway segments: red for 0–19 mph, orange for 20–29, yellow for 30–39, blue for 40–49, and green for 50 and above.

Now, thanks to information more recently saved to the web server, users can click on any roadway segment and access the precise distance of that segment along with its average speed and actual travel time. In addition, users may click below the map on the name of any freeway shown on the map to see a summary of detailed data on the entire freeway.

HOU Real-Time Traffic Map Web site.

This spring, during Phases III and IV of the AVI project, TTI researchers will install sensors along other freeways in Houston. These freeways will be added to the real-time map this summer.

"Although we developed this program specifically for the AVI project, the traffic map has numerous ITS applications in Houston," Hickman says. "In the future we hope to offer added information from other TranStar projects including loop detector data, incident logs, and roadway construction reports."

The Houston Real-Time Traffic Map is located on the Internet: http://herman.tamu.edu/traffic.html

Reprinted with minor editing from TTI's *Researcher* 32(Spring 1996): 9.

INSIDE TQ

BRIDGES

New Wind Load Specs Yield More Realistic Answers and Potential Cost Savings 12

Statewide System for Prioritizing Bridge Projects to Continue 17

COMPUTERS

Clearing the Air: New Model Rates Projects for Air Quality Benefits 6

The Road Knows: AVI Implementation Shows Success 18

CONSTRUCTION

Clearing the Air: New Model Rates Projects for Air Quality Benefits 6

Update on TxDOT Metrication Efforts 14

IRF Calls for EU Truck Charge Proceeds to Be Invested in Environmentally Friendly Roads 16

DESIGN

"Galloping" Signal Arms: A Method to Damp the Motion 1

New Wind Load Specs Yield More Realistic Answers and Potential Cost Savings 12

ENVIRONMENTAL ISSUES

Clearing the Air: New Model Rates Projects for Air Quality Benefits 6

IRF Calls for EU Truck Charge Proceeds to Be Invested in Environmentally Friendly Roads 16

MAINTENANCE

"Galloping" Signal Arms: A Method to Damp the Motion 1

Microsurfacing: Correct Application Will Effectively "Smooth the Way" 9

METRICATION

Update on TxDOT Metrication Efforts 14

TRAFFIC OPERATIONS

Clearing the Air: New Model Rates Projects for Air Quality Benefits 6

The Road Knows: AVI Implementation Shows Success 18

TRANSPORTATION ISSUES

IRF Calls for EU Truck Charge Proceeds to Be Invested in Environmentally Friendly Roads 16

Texas Department of Transportation

RESEARCH MANAGEMENT COMMITTEE MEETING

June 2-6, 1997
La Quinta Conference Center
825 N. Watson Road, Arlington, Texas
Reservations 1 (800) 453-7909
by May 2, 1997 (cut-off date)

June 2 (1:00 pm) — June 3 (5:00 pm)

RMC 4 "Roadway Planning and Design"
RMC 5 "Structures"
RMC 8 "Construction and Maintenance"

June 4 (8:00 am) — June 5 (12:00 pm)

RMC 1 "Management and Policy"
RMC 3 "ROW, Hydraulics, and Environmental Conservation"
RMC 7 "Materials"

June 5 (1:00 pm) — June 6 (5:00 pm)

RMC 2 "Multimodal Operations"
RMC 6 "Pavements"
RMC 9 "Traffic Operations"

Direct any questions to:

Dana Herring, DHERRIN (inside TxDOT)
DHERRIN@mailgw.dot.state.tx.us
(512) 465-7644 or
Debbie Hall, DHALL1 (inside TxDOT)
DHALL1@mailgw.dot.state.tx.us
(512) 465-7684
Fax (512) 465-7486

TECHNOLOGY TRANSFER & LIBRARY SERVICES

Manager: Debbie Hall
(512) 465-7684

★

Editor/Tech. Writer: Kathleen Jones
(512) 465-7947

★

Editor/Tech. Writer: Kay Lee
(512) 467-3882

★

Librarian: Dana Herring
(512) 465-7644

Technical Quarterly
c/o Kathleen M. Jones, RTT, TxDOT,
P.O. Box 5080, Austin, TX 78763-5080