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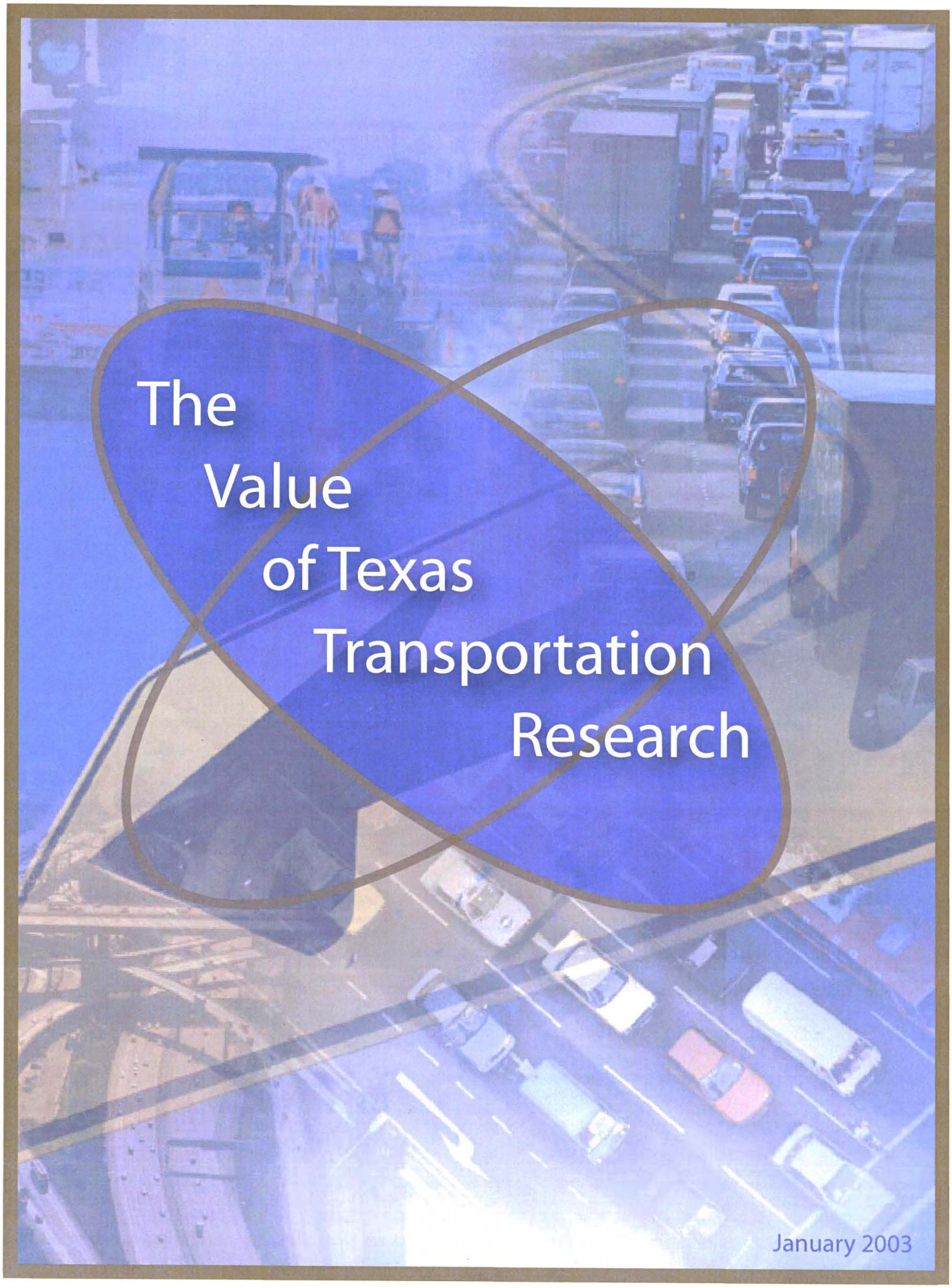


The Value of Texas Transportation Research

January 2003

The Value of Texas Transportation Research

The Texas Department of Transportation (TxDOT) is tasked with planning, building, maintaining, maximizing, and managing the Texas transportation system. The underlying foundation of our work is a vigorous research program. That's where our professionals look for innovations in safety, cost savings, and project delivery.

The nature of research is to take you somewhere you have never been before. It's through technical exploration that we discover new ways to approach old problems. At TxDOT, our research touches the life of every driver every day. It saves lives, it saves money, and it saves time. This report will look as some recent TxDOT research initiatives and how they've changed the way we do business.

To demonstrate the impact that research has on transportation system safety and cost-effectiveness, 21 improved technologies and methods produced by TxDOT's research program were selected from a three-year period, 1999 through 2001. The selected products are considered to be among the best of over 200 beneficial initiatives implemented from those three years of the research program. A benefit period of ten years was used for determining the returns from the selected research program products. This is a conservative assumption, since many benefits never become truly obsolete as newer technology is layered on earlier innovation.

The primary focus of the benefit analysis was on reductions in the number of fatalities occurring on the transportation system, reductions in the number of accidents, and operational cost savings for the department. The operational cost savings described here are limited to reductions in taxpayer cost to provide and maintain the transportation system. The enormous economic value to Texans resulting from reductions in congestion, accidents, and fatalities is not included in the operational cost savings totals.

The analysis also includes several products that produced valuable environmental and societal benefits, rather than definable savings in operational costs, reduced fatalities, or reduced accidents. The development of an improved technology for determining air quality impacts of alternative planning scenarios is an excellent example. Another example presented will help reduce congestion in metropolitan areas while generating revenue to help pay for the implementation of the improved technology.

Table 1 includes the savings estimated for each of the analyzed products and the total savings in the three primary benefit areas. The total values at the bottom of Table 1 demonstrate that research is a critical contributor to both transportation safety and making the transportation system in Texas more affordable.

The estimated number of lives to be saved, 245 over ten years, and the reduction in accidents, 24,960 over the same period, clearly indicate the importance of the research program to transportation safety in Texas. Improvements in safety developed by TxDOT research are undoubtedly major contributors to the decreases in crash rates being experienced. Although crash rates are falling, the growths in number of drivers and number of miles being driven on our system have caused total annual fatality and crash numbers to remain nearly constant over recent years. Without the continuous effort to make our roadways safer, the dramatic annual increase in miles being driven in Texas would have caused a similarly dramatic increase in annual fatalities and accidents.

The estimated ten-year cost savings in department operations, stemming from these 21 research products, are more than $322 million. The research program budget total for fiscal years 1999, 2000, and 2001 was approximately $54 million (less than 0.4% of the department's budget). The total operational cost savings derived from these 21 products exceed the cost of the research program by approximately $268 million. This is a net return on investment ratio of 5:1, without considering the value of the numerous other products implemented from that three-year period of the research program.

Since the department routinely makes decisions involving hundreds of millions of dollars, cost savings from a single research project will occasionally offset the cost of the entire research program for several years. This is the case with the research project that developed criteria for the use of an alternative roadway design for rural two-lane highways (Super 2 Geometric Design). The cost savings resulting from that research project are conservatively estimated at $150 million over ten years. The development of roadway applications for the use of ground penetrating radar is expected to save the department $57 million over the next ten years.

The program also returns benefits beyond those that can be measured project by project. TxDOT relies heavily on the cooperative university research program to develop innovative technologies and improved methods. This program benefits both TxDOT and the public universities in Texas. While TxDOT, and then the state's transportation system, receive improved technologies and solutions to transportation challenges, university faculty members gain valuable experience applying theory to real-world situations. The research projects also provide opportunities for graduate students to expand knowledge and interest in the transportation field.

This brief analysis of the value of research clearly indicates that a strong program is vital to effectiveness of Texas Department of Transportation operations and services. Funding for transportation research is an investment that results in saved lives and more than returns its cost in terms of operational efficiency.

Descriptions and additional information are provided on each of the analyzed research products in the pages following Table 1.

TABLE 1. Projected Ten-Year Benefits from Selected TxDOT Research Products Developed Between 1999 and 2001

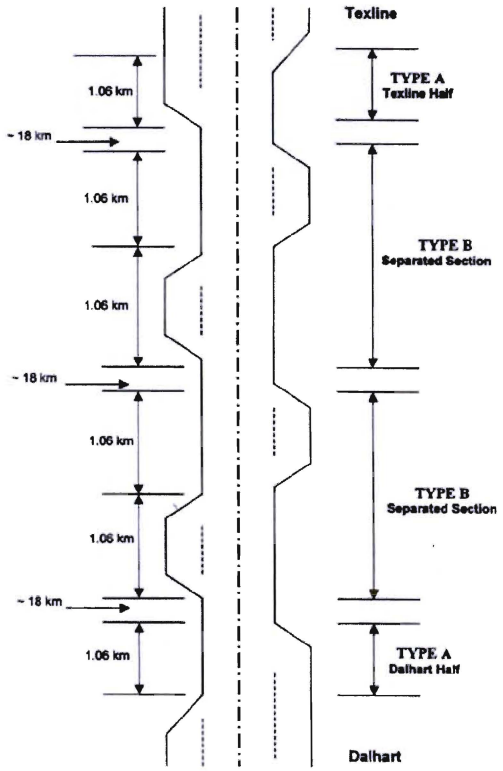
Improved Technology	Lives Saved	Accidents Reduced	Operational Costs Saved
Super 2 Geometric Design Guidance	-	-	$150,000,000
Improved Guidelines for Frontage Road Driveway Spacing	33	5,200	$230,000
Ground Penetrating Radar Testing of Pavements	-	-	$57,000,000
Method for Determining Effectiveness of Transportation Control Measures in Ozone Non-Attainment Areas	Environmental Stewardship		
Sign Crew Field Book	-	-	$4,750,000
Truck Monitoring and Warning System for Freeway-to-Freeway Connections	70	2,600	-
Structural Assessment Method for In-Service Bridges	-	-	$9,000,000
Criteria for Using 0.6-inch Diameter Prestressing Strand with High Strength Concrete in Pretensioned Girders	-	-	$24,000,000
Generic Crashworthy Work Zone Traffic Control Devices	70	8,000	$23,500,000
Guidelines for High Occupancy/Toll Lanes in Texas	Congestion Reduction		
Precast Concrete Bent Caps	-	-	$9,000,000
Seal Coat Constructability Review	-	-	$17,500,000
Pavement Surface Texture Measurement System	12	1,100	$5,922,000
Model Border Crossing Design	Economic & International Relations Benefits		
Strengthening Existing Structures with FRP Composites	-	-	$3,000,000
Micro-Deval Aggregate Test	-	-	$1,495,000
Design Guidelines and Construction Specifications for Continuous Flight Augercast Piles	-	-	$4,000,000
GIS-Based Floodplain Maps and Design Applications	-	-	$660,000
Erosion Function Apparatus and Scour Design Method	-	-	$1,620,000
Analysis of Small Target Visibility Method	-	-	$10,750,000
Alternate Polish Value and Soundness Specification Requirements (New Wet Weather Accident Reduction Program)	60	8,060	-
Totals	**245**	**24,960**	**$322,427,000**

Super 2 Geometric Design Guidance

This research project developed criteria and guidelines for use of Super 2 geometric design by the Texas Department of Transportation. Super 2 geometric design provides intermittent passing lanes on two-lane rural highways where safety and capacity modifications are needed but average daily traffic (ADT) does not require an upgrade to a four-lane configuration.

On rural two-lane highways, Texas drivers are known to pull onto the shoulder to let a vehicle pass. Thus, where paved shoulders are wide, the alternative that Super 2 provides is essentially to stripe the roadway as Texas drivers actually drive it. Where shoulders are narrow, providing Super 2 intermittent passing lanes still provides a tremendous construction cost savings compared to other alternatives for increasing passing safety and highway capacity.

There are more than 57,000 miles of two-lane rural highways in Texas. It is estimated that 68 percent of rural travel and 30 percent of all travel occur on two-lane roads. Developing and increasing use of low-cost safety and capacity improvements such as Super 2 are highly advantageous in stretching available funding in Texas.



Super 2 design schematic

Benefits

- Super 2 geometric design provides improved highway safety and capacity for two-lane rural highways with less than 4,200 ADT.
- The intermittent passing lane allows drivers an opportunity to safely pass slower moving vehicles every several minutes.
- The Super 2 concept adds little additional cost to rehabilitation projects, with little or no right-of-way adjustment.
- Use of Super 2 geometric design in lieu of converting a two-lane roadway to four lanes saves approximately $50 million for a typical twenty-five mile section of rural highway. A conservative estimate is that the improved design criteria and guidelines will result in construction of at least one additional Super 2 section every three years.

Impact Over First Ten Years:

$150,000,000 Saved

Improved Guidelines for Frontage Road Driveway Spacing

This research project examined the relationship between frontage road driveway access and freeway ramp location. Access on the frontage road in close proximity to freeway ramps can increase the amount and severity of weaving, lead to more accidents, and add to congestion.

Vehicle attempting to enter freeway from frontage road driveway

The researchers collected and analyzed traffic and accident data from several Texas urban areas including San Antonio, Houston, Dallas, and Austin. Using the collected field data, simulations were run to determine minimum and desirable driveway spacing along frontage roads from freeway entrance and exit ramps.

The research was of considerable benefit to TxDOT, with minimum and desirable driveway spacing being incorporated into TxDOT's Design Manual. The research demonstrated that these new standards have the potential to reduce accidents up to 50% in frontage road weaving sections.

These standards are being applied in new areas being developed along frontage roads. In established areas along frontage roads, the new criteria will be applied as redevelopment takes place.

Benefits

- There will be a substantial reduction in the number of accidents occurring in the weave areas of urban frontage roads. Models show that the new standards will result in about 5,200 fewer accidents over the next 10 years. When fully implemented, the driveway standards should result in 3,800 fewer accidents every year on Texas frontage roads.

- The new standards will also save lives. It is expected that there will be 33 less traffic fatalities over the course of the first 10 years. At full implementation statewide, there should be 25 fewer vehicular fatalities every year.

- In addition to traffic accidents, there will be savings to TxDOT in terms of staff time for accident investigation, accident data collection and record maintenance, on-scene response, and replacement of damaged roadside appurtenances. Estimated cost savings for TxDOT are projected to be about $230,000 over the first ten years.

- As a result of fewer accidents, motorists will also benefit. Based on the anticipated elimination of 5,200 accidents, user delay savings are estimated to be over 1.5 million person-hours within the initial ten-year period.

Impact Over First Ten Years:		
33 Lives Saved	5,200 Accidents Prevented	$230,000 Saved

Ground Penetrating Radar Testing of Pavements

Ground penetrating radar (GPR) is a pavement evaluation technique that quickly identifies characteristics of pavement layers. GPR allows the user to "see" underground into a pavement's substructure. Originally developed outside of the transportation industry, Texas research has been instrumental in improving this technology while applying it to roadway testing.

GPR mounted on the front of a vehicle

GPR obtains nearly continuous readings along a pavement and detects anomalies, telling the user where the pavement is the same and where it's different. This technique can, for example, find areas of moisture damage that would otherwise be difficult to locate. GPR also provides information about pavement layer thicknesses. It pinpoints those areas where coring or other types of pavement testing should be done, thereby reducing the number of other tests that disrupt traffic flow.

Ground penetrating radar provides important information about sections of pavement being considered for reconstruction. Pinpointing areas requiring deep repairs reduces costs. For example, an $8 million Houston pavement rehabilitation project was reduced to $6 million when full-depth repairs were found unnecessary in many places. Training and educational tools developed in this research, including videos, are providing TxDOT personnel with a thorough understanding of GPR equipment, techniques, and uses, allowing expanded usage across the state.

Benefits

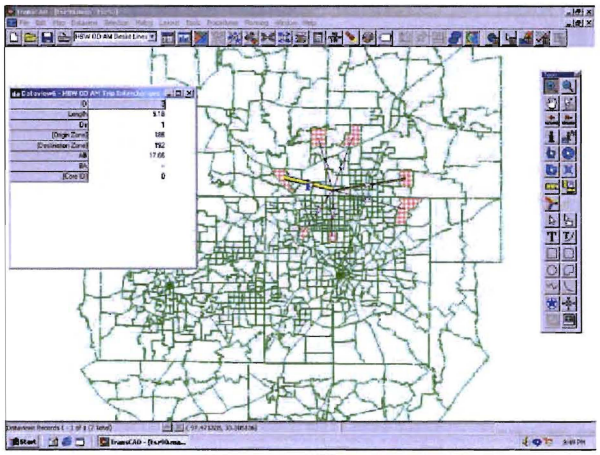
- GPR significantly reduces costs of multi-million dollar rehabilition projects when problems deep in the pavement structure are isolated and can be repaired individually.
- GPR data can be collected at highway speeds with no disruption of traffic flow.
- GPR testing reduces the need for pavement coring and Falling Weight Deflectometer (FWD) testing.
- GPR is nondestructive, easy to use, and safe.
- GPR provides a continuous measure of the pavement thickness.

Impact Over First Ten Years:

$57,000,000 Saved

Method for Determining Effectiveness of Transportation Control Measures in Ozone Non-Attainment Areas

This research project developed an integrated and coordinated regional transportation planning and emissions modeling procedure that determines the impact of Transportation Control Measures (TCMs) on mobility and emissions. Transportation professionals planning mobility projects must consider public environmental concerns such as air quality, especially in ozone non-attainment areas. This requires a coordinated effort among the transportation stakeholders to ensure the provision of safe and efficient transportation systems while also addressing environmental concerns.



Software screen showing map of DFW analysis area

The research resulted in the development of a GIS-based travel demand model that is sensitive to environmental policy and provides improved assessments of TCM effectiveness in ozone non-attainment areas. The model is imbedded in TRANSCAD software and is used to estimate mobility and emission changes due to TCM implementation. The model can be used by both Metropolitan Planning Organizations (MPOs) and TxDOT to streamline the transportation conformity process.

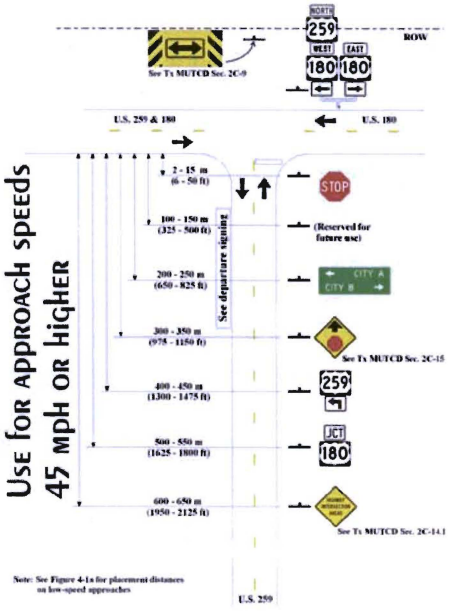
Benefits

- The estimation of TCM-induced emission changes, used to show conformity with emission budgets, is more accurate.
- Both TxDOT and MPOs are provided with the capability to directly assess and forecast the impact of TCMs.
- Transportation professionals can make better environmental policy decisions because the new model accommodates the change in number of trips due to the implementation of TCMs.
- Improved ability to quantify Congestion Mitigation and Air Quality (CMAQ) Improvement Program projects will enhance the effectiveness of their implementation.
- Forecasting of needed transportation improvements is enhanced by improved visualized urban traffic patterns from the integrated GIS-based system.

Sign Crew Field Book

Rural guide signing practices and effectiveness were evaluated through department-sponsored research. A product of that study was a Sign Crew Field Book (SCFB), created by a team of university researchers, TxDOT, and FHWA staff. The purpose of the SCFB was to improve the effectiveness and placement consistency of signs on conventional rural highways. It was developed initially for use by field crews to supplement and expand upon the guidelines contained in the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

The SCFB provides information on the field placement of regulatory, warning, and guide signs; location and placement of object markers, delineators, and barrier reflectors; and location and installation of mailboxes. The SCFB does not supersede the TMUTCD, but provides additional guidance with respect to standards, recommended practices, and other requirements established by TxDOT.



Example figure from the Sign Crew Field Book

Since its initial publication, the Sign Crew Field Book has been one of the most popular documents distributed by the Traffic Operations Division. It has been widely distributed to TxDOT maintenance sections and can be found in almost every sign truck in the state. Area and district offices are also using the document when designing the sign portion of highway plans.

Benefits

- The SCFB helps sign crews place signs more consistently and effectively throughout the state. Effective signing helps drivers find their destinations more safely and easily.
- Sign crews can now provide drivers with more advance information at intersections. This has been accomplished by moving signs further from the intersection on the approach.
- A "no sign zone" is another concept implemented through the SCFB to help driver understanding.
- The heavy use of figures and tables makes the SCFB easy to understand and apply in the field.
- An estimated $475,000 is being saved each year by TxDOT through increased efficiency of department sign crews.

Impact Over First Ten Years:

$4,750,000 Saved

Truck Monitoring and Warning Systems for Freeway-to-Freeway Connectors

This project developed a truck monitoring and warning system for detecting trucks traveling at excessive speeds on freeway-to-freeway interchange ramps. Trucks that may be too long or too high to safely negotiate these ramps are also monitored. The truck monitoring and warning system operates by activating displays to warn the truck drivers of potential hazards as their vehicles approach the curved section of an interchange ramp.

Truck accident at IH 10 connector in San Antonio

The system uses three infrared light-beam sensors with a special microcontroller-based signal processor to determine the speed, length, and arrival time for vehicles. The light beam is installed at a height of seven feet above the roadway in order to monitor only the trucks. When selected criteria are met, the signal processor sends a warning message to the driver.

Results of this research indicated that when trucks exceeded the preset criteria, the actuated flashing warning yellow lights caused trucks to reduce their speed an additional 2 miles per hour below the normal design speed before the trucks entered the curved portion of the ramp.

The department is in the process of implementing these warning systems at a number of locations.

Benefits

- It is estimated that 70 lives will be saved and 2,600 accidents will be prevented in Texas over 10 years as the truck monitoring and warning systems are installed at all problem freeway interchange ramps.
- The truck monitoring and warning system specifically targets large, fast-moving trucks on freeway interchange ramps.
- The truck monitoring and warning system is low cost, low maintenance, and reliable.
- User savings of approximately 1 million person-hours, over 10 years, will result from the reduced number of truck incidents at freeway interchanges.

Impact Over First Ten Years:	
70 Lives Saved	2,600 Accidents Prevented

Structural Assessment Method for In-Service Bridges

There are many structures in Texas exhibiting premature concrete deterioration attributed to alkali-silica reactivity or delayed ettrengite formation. Pretensioned concrete girders exhibiting this type of distress typically exhibit widespread map cracking as well as cracks running longitudinally along the length of the girder. Visually, these cracks may be quite disturbing to the structural engineer and travelling public, calling into question the structural integrity of the girder.

Prestressed concrete beam with Premature Concrete Deterioration

TxDOT research was conducted to help decide whether repair or replacement of these deteriorating structures was necessary. The project determined how to quantify the amount and rate of deterioration, and how it affects the strength of these bridges. Research results show that flexural capacity of the deteriorating girders is virtually unchanged when compared to that predicted for undamaged girders. Shear capacity was found to be reduced approximately 14% for girders exhibiting moderate damage, but remains above the minimum required by code. Based on the favorable results from this research, TxDOT will not be replacing any of these deteriorated girders in the foreseeable future.

Benefits

- The primary benefit of this research is confidence in the structural integrity of in-service structures exhibiting premature concrete deterioration.
- Because the research showed that flexural capacity is virtually unchanged, and shear capacity is reduced only 14% or less, the urgency to replace these girders has been removed.
- The research provided a simple, nondestructive method of monitoring and evaluating the progression of premature concrete deterioration. TxDOT engineers and inspectors will utilize the Damage Index concept for continued monitoring of prematurely deteriorated girders.
- There are currently over 50 Texas structures exhibiting premature concrete deterioration. Of these, some 35 exhibit enough visual distress to have been serious candidates for removal and replacement. Assuming, that over a 10-year period, the superstructures of approximately 50% of these 35 structures would have been removed and replaced, savings of approximately $900,000 per year in bridge replacement costs are being realized.

Impact Over First Ten Years:

$9,000,000 Saved

Criteria for Using 0.6–inch Diameter Prestressing Strand With High Strength Concrete in Pretensioned Girders

The development of high performance concretes in recent years, including high strength concrete, has offered significant improvements in terms of durability and strength for concrete structures. The advantages of high strength concrete for pretensioned concrete beams are more fully realized with the use of larger diameter 0.6-inch prestressing strand, which allows 40% more force to be applied than the same number of 0.5-inch diameter strands.

High Strength Concrete girders, Louetta Road overpass structure at US 59, Houston.

A moratorium was placed on the use of 0.6-inch diameter strand by the Federal Highway Administration (FHWA) after research at North Carolina State University pointed to inconsistencies in the calculation of transfer and development lengths for prestressing strand of varying diameters. TxDOT research developed design procedures for the safe and efficient use of 0.6-inch diameter strand in pretensioned concrete girder applications. In part as a result of this research, the federal moratorium on the use of 0.6-inch diameter strand has been lifted, making the full benefits of high strength concrete possible, including increased beam spacings and longer span lengths in prestressed concrete beam bridges. As with most new innovations, achieving full implementation takes time.

Benefits

- The longer span lengths now possible allow bridge designers greater flexibility in layout and location of new bridges.
- With longer spans, the number of required spans is reduced. This translates into fewer required bent caps, bearing pads, columns and foundations, positively affecting construction cost and speed of construction.
- Due to increased potential load-carrying capacity of individual girders, the spacing between girders may be increased, resulting in fewer total numbers of girders required. Fewer girders per span significantly reduces the cost of the superstructure.
- Annual savings of $4 million are projected based on a reduction in the number of beams in future bridge structures in Texas, made possible by wider beam spacings.

Impact Over First Ten Years:

$24,000,000 Saved

Generic Crashworthy Work Zone Traffic Control Devices

The Texas Department of Transportation (TxDOT) continues to be proactive in providing safer routes through construction work zones for the traveling public. TxDOT-sponsored research projects have resulted in the development of many crashworthy breakaway supports for traffic control devices that reduce the probability of injury or death when these devices are impacted by an errant vehicle.

Barricades and temporary signing in construction work zone

Work zone traffic control devices such as barricades and temporary sign supports are critical to the proper function and delineation of work zones. However, these devices can also constitute hazards to vehicle occupants and work zone personnel when struck by an errant vehicle. Full-scale crash testing demonstrated that some of the standard work zone traffic control devices used by TxDOT were not crashworthy. The alternatives were to require expensive proprietary devices or to develop new low-cost, generic devices that are functional and easy to fabricate. TxDOT chose the latter alternative and several low-cost, generic barricades and temporary sign supports fabricated from readily available materials were successfully developed and tested under this research project.

TxDOT used the results of in-service performance evaluations and feedback from field crews and contractors to assess the performance of roadside safety devices and several types of roadside safety hardware. Also, crash tests were conducted on the new devices to assure crash worthiness. These crash tests were conducted in accordance with national crash testing standards. Devices included in the investigation were various work zone traffic control devices, consisting of barricades and temporary sign supports.

Benefits

- Generic work zone traffic control devices are non-proprietary and cost-effective, which saves TxDOT approximately $75-100 per barricade and $100-150 per sign support. The estimated annual savings to TxDOT is $2,350,000.
- Barricades and temporary sign supports now comply with NCHRP Report 350 crash testing standards. They are estimated to reduce the number of work zone related traffic deaths by 7 each year.
- Generic work zone traffic control devices are easily fabricated from commonly available materials.
- A savings in motorist delays of approximately 3.2 million person-hours is anticipated over 10 years, based on reduced traffic congestion in work zones.

Impact Over First Ten Years:		
70 Lives Saved	8,000 Accidents Prevented	$23,500,000 Saved

Guidelines for High Occupancy/Toll Lanes in Texas

This research project examined the feasibility of implementing high occupancy toll (HOT) lanes in Texas. HOT lanes are limited access facilities that give preference for free usage to higher occupancy vehicles and allow access to lower occupancy vehicles by assessing a toll. The research produced guidelines that explained how a toll/occupancy option could be implemented on existing high occupancy (HOV) lanes that were under- or over-utilized.

High Occupancy Vehicle lane in Houston

The guidelines that were developed assisted TxDOT in making key decisions regarding the use of tolling on HOV lanes. In the case of the initial HOT lane project on the Katy Freeway (I-10) in Houston, the over-used HOV lane was very congested with 2-person carpools (HOV2s) in the late 1980s. Raising the occupancy requirement to HOV3 solved the congestion problem, but eliminated many carpools and left the HOV lane under-utilized. However, as the research demonstrated, allowing HOV2s to "buy-in" to the HOV lane improved their travel options, and removed cars from the general purpose lanes.

Currently in Houston, two freeways, the Katy and the Northwest (US 290), use the HOT lane concept for HOV2s. The LBJ (I-635) reconstruction project in Dallas has the most significant HOT lanes yet contemplated in Texas. At least four HOT lanes are planned as a part of the project. Similarly, the Katy reconstruction plans call for four HOT lanes.

Benefits

- The major benefit is that properly implemented HOT lanes reduce congestion on the general purpose lanes.
- Since the inception of the HOT lane concept in 1998, the total benefits to road users from reduced delays on the Katy and Northwest Freeways are valued at approximately $600,000. However, with added HOT lanes being incorporated in the future reconstruction of the Katy and LBJ Freeways, the value of user delay benefits is projected to be $80 million over ten years.
- To date, TxDOT has collected about $335,000 in toll revenues on the Katy and Northwest Freeways. These and future revenues generated over the next ten years will help offset costs associated with providing HOT lanes.
- Making better use of the HOV lane to reduce peak hour congestion can postpone major investments to widen the facility.
- HOT lanes improve air quality because of reduced emissions from vehicles that would have otherwise been idling in heavily congested lanes.

Impact Over First Ten Years:

Congestion Reduction in Metropolitan Areas

Precast Concrete Bent Caps

Typically, bent caps are constructed of reinforced concrete which is cast in place on top of bridge columns. Typical cast-in-place construction techniques require form setting, reinforcing steel placement, concrete placement and curing, and form removal to occur in an elevated setting, often 20 feet or more in the air. The bent cap concrete, which is placed by crane bucket or pumped, must meet strength and time requirements prior to form removal and subsequent setting of bridge beams, which bear upon the bent cap.

Precast bent cap being placed into position, SH 66 bridge over Lake Ray Hubbard.

Significant advantages in terms of time, cost, safety, and quality may be realized through use of precast bent caps in lieu of conventional cast-in-place construction.

TxDOT research developed connection details and grouting requirements to allow increased use of precast bent caps during bridge construction. Precast bent caps have been utilized on the IH 45 Pierce Elevated Freeway rehabilitation project in Houston and the SH 66 Lake Ray Hubbard bridge replacement project in Rockwall, and are currently being used on the replacement of the SH 36 bridge over Lake Belton.

Benefits

- Worker safety is increased considerably for contractor work force and TxDOT construction inspectors, since most work is performed on the ground instead of in an elevated situation.
- Bridge structure quality is increased, since work is performed in a more controlled environment and is more readily accessible for quality control and quality assurance activities.
- When fully implemented, the estimated annual cost savings to TxDOT, over conventional cast-in-place bent caps, is $1,000,000.
- A major benefit made possible by precasting bent caps is an annual reduction of 300 days in time that construction work zones and barricades are on our roadways. Construction time savings have been determined to be 5-7 days per precast bent cap.
- The estimated annual reduction in number of motorist hours wasted due to traffic delays associated with work zones is 950,000 hours.

Impact Over First Ten Years:

$9,000,000 Saved

Seal Coat Constructability Review

Seal coating is the primary method of protecting structural integrity and restoring skid texture of the thousands of miles of moderate to low traffic roadways of the Texas system. Selecting the asphalt application rate for a seal coat on a given section of roadway requires consideration of many factors particular to that roadway and the materials involved. This decision is among several that must be made based on many years of experience rather than specifications or tests. These decisions, however, are the most important factors in determining the useful life of the seal coat being placed. As the department has lost a great many experienced seal coat personnel to retirement in recent years, research provided major benefits to help bridge this experience gap.

Application of aggregate during seal coat construction

A "constructablity review" is a formal and thorough review of statewide operations with a primary purpose of identifying best practices. In this case, researchers examined TxDOT's seal coat process from planning to construction completion, focusing on the portions of the process that are inherently variable or difficult to accomplish. The review included visiting all TxDOT districts, viewing 9,000 miles of seal coated pavements, and interviewing over 300 TxDOT personnel involved with our seal coating operations.

Researchers first identified those construction practices, knowledge, and tricks of the trade that help produce long seal coat service life. Next, they developed a district training program, addressing the five essential elements of seal coat operations: seal coat planning and design, materials, construction quality assurance, equipment and construction, and contract issues. Finally, the researchers retraced their steps to all districts, sharing the wisdom and best practices they found.

Benefits

- Best practices from individual TxDOT districts have been identified, captured, documented, and shared with all districts, thereby strengthening TxDOT's technical expertise in this critical area of our operations.

- As the department expenditures on seal coating operations are approximately $175 million each year, an average increase in seal coat service life of only 1 percent, statewide, results in an operational cost savings of $1.75 million per year. This is considered an extremely conservative estimate.

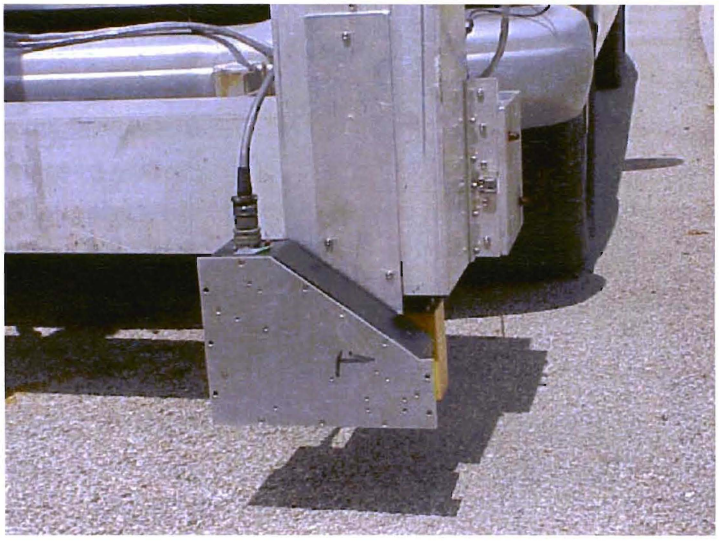
Impact Over First Ten Years:

$17,500,000 Saved

Pavement Surface Texture Measurement System

Skid characteristics of pavements are a major factor determining the safety of the road network. A significant percentage of all accidents are directly related to roadway skid properties. TxDOT presently uses seven trucks and skid trailers to collect skid property data on 25% of the network each year, meaning collecting skid data for the entire network takes about four years.

When fully implemented, the new Pavement Surface Texture Measurement System will allow TxDOT to measure the skid resistance of almost all of the network annually. Skid resistance determinations will be made with a new laser system using macrotexture measurements, which directly correlate to currently used skid numbers. Implementation is expected to be completed in 2003.



The Laser Texture Measuring System mounted on the front of a multi-purpose pavement testing vehicle

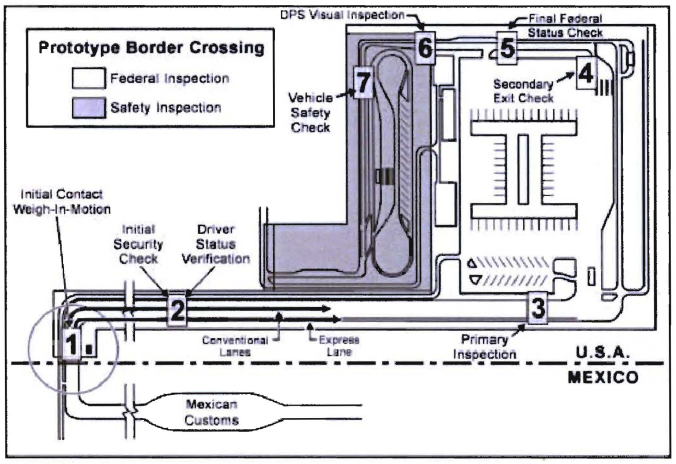
Benefits

- The new system is less expensive to purchase and deploy than currently used skid trailers. The new non-contact skid system offers reduced operating costs in terms of skid tires, operator hours, and maintenance of the trailers. Since the new system will be mounted on vehicles performing other functions, seven vehicles previously dedicated to collecting this data are no longer needed.
- Sections of pavement approaching unacceptable skid properties will be identified earlier since skid data will be collected on the majority of the network every year.
- Non-contact skid data will be collected for the continuous surface of the roads. The current system takes measurements at 0.5-mile intervals.
- Data will be collected at prevailing traffic speeds, reducing the likelihood of accidents associated with collecting skid test data.

Impact Over First Ten Years:		
12 Lives Saved	1,100 Accidents Prevented	$5,922,000 Saved

Model Border Crossing Design

In the late 1990s, with increasing NAFTA traffic, backups at the border had become a severe problem. Currently, Texas has 26 vehicular border crossings with Mexico, and many continue to experience severe congestion caused by the growth of NAFTA traffic, as well as inefficient interaction among inspection procedures and traffic management. As a result of the increasing congestion, a project was begun in 2000 to develop criteria and a model border crossing design. A prototype design has been developed under this project. The design is currently being refined and adapted to the site conditions at each crossing. It allows electronic pre-clearance of the driver, vehicle, and load, as well as the use of an express lane. Implementation is expected to begin in 2003. When the design is fully implemented at each border crossing, it will result in significant improvements in commercial traffic flow.



Prototype design for a border crossing

The model border crossing represents innovative technology and increased coordination among international, federal, and state agencies. In addition to reducing delay, the design will result in reductions in air pollution caused by idling vehicles, and will deliver goods to market more quickly and economically.

Benefits

- Approximately 70 percent of the 3 to 4 million trucks crossing the Texas-Mexico border each year can be pre-cleared. Total processing time will be reduced from hours to less than 15 minutes for pre-cleared trucks.

- Savings to motorists, specifically truckers, are significant. Assume 70% of 3 million trucks save only 30 minutes each, which equates to 1.05 million truck hours. The value of truck time is $25 to $35 per hour. Costs to deliver goods by trucks will be reduced by at least $25 million per year.

- Possible savings to the U.S. economy range from $30 million to $60 million per year.

- Other non-quantifiable benefits include considerable reductions in air pollution from idling trucks, and improved cooperation at the border between Mexican and U.S. federal and state agencies.

Strengthening Existing Structures With FRP Composites

Design loads for bridges have steadily increased over the years to accommodate increasing levels of heavy truck traffic. There has been a critical need to develop techniques to strengthen older, existing structures to keep up with current loadings.

Full-scale testing of FRP-strengthened pan girder bridge.

Federal funding requirements stipulate that unless older, existing bridges meet certain minimum load criteria, federal dollars cannot be spent on these structures for rehabilitation efforts (for example, widening an existing bridge). This situation often leads to costly removal and replacement of existing bridges which, while still structurally sound, were designed and constructed for older traffic loading conditions. TxDOT research developed and refined strengthening techniques for increasing the load carrying capacity of existing pan girder, flat slab, and T-beam bridges by means of bonding high-strength fiber reinforced polymer (FRP) composite sheets to existing reinforced concrete structural members. FRP composite materials were originally developed by the aerospace industry.

Benefits

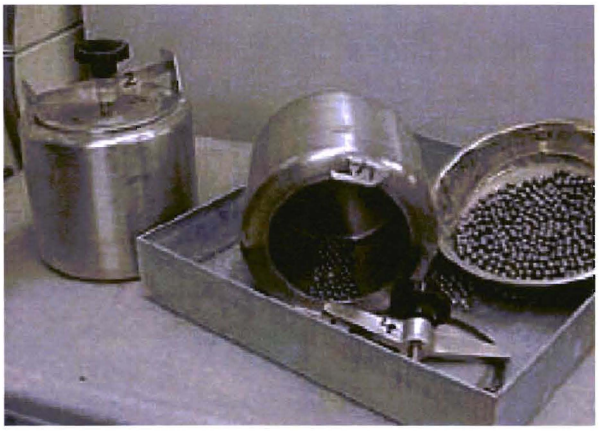
- Field application of FRP composite sheets are relatively simple and require minimal preparation work or special equipment.
- Bridge structural capacity can be increased without an increase in structure depth.
- This new rehabilitation method provides an economic alternative to replacement of bridges designed under older loading criteria.
- Historically significant structures can be preserved with minimal visual impact.
- Construction time is significantly reduced compared to total structure replacement, resulting in reduced motorist detour time.
- TxDOT's first implementation occurred in 2001, saving approximately $82,000 in replacement costs on a single structure. As implementation progresses to the projected rate of 5 structures per year receiving this treatment (strengthened and widened as opposed to removed and replaced), total annual savings will be in excess of $400,000.

Impact Over First Ten Years:

$3,000,000 Saved

Micro-Deval Aggregate Test

The Micro-Deval (MD) test is an alternative test method to the five-cycle Magnesium Sulfate Soundness (MSS) test for evaluating paving aggregates. It measures aggregate durability.



Container and steel balls used in Micro-Deval test

In this test method, a sample of coarse aggregate is immersed in water for one hour and then placed in a steel drum with two liters of water and an abrasive charge consisting of steel balls. The jar, aggregate, water, and charge are then rotated for two hours (12,000 revolutions). At the end of two hours the aggregate is oven dried and the amount of degradation is determined and reported as the Micro-Deval loss (%). More durable aggregate will experience lower losses.

The Texas research validated the appropriateness of the test method and established criteria for Texas aggregates and pavement conditions.

Benefits

- The Micro-Deval test can be completed in one day, compared to six days needed to complete the Magnesium Sulfate Soundness (MSS) test currently used.
- The test is very repeatable, having only one-fourth the variability of the test currently used. The test is also less sensitive to test conditions and operator experience.
- The test can also be used as a production quality control tool by the aggregate producer, as it can provide timely information about the quality and consistency of the material being produced.
- The test can be used as a job-control test to verify that an aggregate stockpile is consistent with the source rating.
- It can be used to supplement the MSS test data. The Micro-Deval test allows more frequent testing of aggregate sources with high variability and/or high production rates. This new test can be used as an additional requirement for special, high-performance asphalt and concrete mix designs.
- Annual savings in time of TxDOT laboratory technicians is valued at $193,000.

Impact Over First Ten Years:

$1,495,000 Saved

Design Guidelines and Construction Specifications for Continuous Flight Augercast Piles

Virtually all bridge foundations constructed in Texas are either driven piles or drilled shafts. Driven piles are used extensively in the coastal areas where soft ground conditions exist. Pile driving operations are loud and noisy, and they can cause settlement of nearby structures due to vibration.

Drilled shafts are the most prevalent bridge foundation type in Texas. However, drilled shafts must often be constructed with the aid of bentonite slurry to keep the shaft from closing in while being drilled, unless expensive steel casing is installed. The bentonite slurry hinders inspection of the shaft, and is considered by many to be an environmental nuisance, representing a disposal problem.

CFA pile installation for bridge foundation at Krenek Road and US 290 in Houston.

Continuous flight augercast (CFA) piles have been used successfully for many years in the building construction industry, but have not been used for transportation structure foundations in Texas. CFA piles are installed by drilling a shaft with a continuous flight auger, pumping grout through the hollow auger stem as the auger is withdrawn, and then pushing the reinforcing steel cage into the grout before it sets. CFA piles represent an economical alternative to driven piles and drilled shafts.

TxDOT research developed a design methodology, construction specifications, and inspection guidelines for use of CFA piles for transportation structures. Based on the favorable results of this study, CFA piles are now beginning to be used for bridge and soundwall foundations in Texas.

Benefits

- Currently, TxDOT expends approximately $16,000,000 per year installing driven pilings and drilled shafts in soft soil and rock conditions, where CFA piles are appropriate. Once use of CFA pile construction becomes commonplace, it is reasonable to expect a 5% decrease in this cost due to the presence of a competing, alternate foundation construction system. Annual cost savings for CFA piles are estimated to be $800,000 when fully implemented statewide.
- CFA pile installation is rapid and creates little vibration and noise level.
- If necessary, foundation depth can easily be adjusted in the field based on actual soil conditions.
- No environmental issues are associated with CFA pile construction as is the case with currently used construction methods.

Impact Over First Ten Years:

$4,000,000 Saved

GIS-Based Floodplain Maps and Design Applications

This research project developed improvements to hydraulic and hydrologic calculation procedures, specifically in methods of determining peak discharges, hydrographs, and floodplain maps using geographic information system (GIS) information as the basis for the new software.

GIS map showing areas to be flooded under specified rainfall conditions

A significant part of the cost of most highway projects is attributable to drainage facilities, such as bridges, highway culverts, storm drains, and water quality and quantity control structures. Design of these facilities involves a hydrologic analysis to determine the design discharge and a hydraulic analysis of conveyance capacity of the facility. Although most hydrologic and hydraulic calculation procedures are available in computer programs, the use of which has significantly reduced the mathematical effort involved, a substantial effort is still necessary to establish and manipulate the data required for input into those programs. In this research project, a GIS methodology for assisting in the design of highway drainage structures has been developed.

The research was of considerable benefit to TxDOT. The GIS design methodology reduces the analysis time and improves the analysis accuracy by integrating digital spatial data describing the watershed with standard hydrologic and hydraulic computer packages. The GIS method determines flood peak discharges and provides floodplain mapping visualization in a more timely and accurate manner than previous methods.

The GIS hydrologic and hydraulic design methodology is being implemented by TxDOT and will be the basis for future transportation project hydrologic and hydraulic design.

Benefits

- Accuracy of hydraulic and hydrologic calculations is improved.
- There is substantial reduction in the time required to delineate watersheds and floodplains for proposed transportation projects. This will reduce the hydrologic and hydraulic design times significantly. Improved design staff efficiency results in approximately $120,000 in cost savings annually.
- In addition to the design cost savings, there is some additional benefit to TxDOT in terms of reduced staff time for floodplain investigation, data collection, and record maintenance required for compliance with Federal Emergency Management Agency (FEMA) regulations.

Impact Over First Ten Years:

$660,000 Saved

Erosion Function Apparatus and Scour Design Method

This research project examined the scour rate (erosion rate) of cohesionless soils (sands and silts) and cohesive soils (clays) with respect to bridge foundation design. Current scour design techniques focus on cohesionless soils and ultimate scour depth (maximum erosion around bridge pilings). The research demonstrated that anticipated scour depth of clays is not the same as for sands and silts over the design life of many structures. Therefore, there are construction cost savings to be realized when more accurate scour information is used in design of some of our structures.

Scour of soil from around bridge piers can ultimately lead to structural failure

The researchers developed the SRICOS (Scour Rate in Cohesive Soils) method based on numerical testing, modeling, and actual erosion testing of soils. The SRICOS method uses a new apparatus called the EFA (Erosion Function Apparatus) to test soil for erodibility. A quick field calculation of scour can be made after the EFA test. In practice, soils are tested by the EFA prior to bridge placement in order to determine the scour potential of bridge piers. The EFA yields better scour predictions than standard practice methods. The EFA is now being used in numerous other states.

This improved technology is of considerable benefit to TxDOT. It will save many thousands of dollars each year, and it will reduce the potential of bridge collapse due to scour. Because the SRICOS method using the EFA is a revolutionary development it will take several years to implement statewide. However, significant benefits can be realized in the next few years.

Benefits

- Erosion rate versus shear stress is directly determined, thereby improving the quality of data being made available to bridge designers.
- The risk of bridge failure due to scour is further reduced.
- The over-prediction of scour is reduced by providing a method of field verification.
- The SRICOS method will yield fiscal benefits in design because shallower foundations can be justified in some cases. A conservative estimate is that the research will save in excess of $160,000 per year in design staff and construction costs.
- Bridge site selection and placement will be improved.

Impact Over First Ten Years:

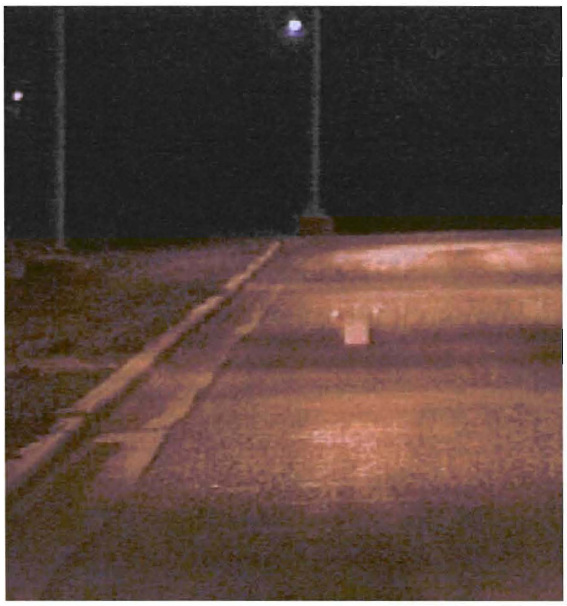
$1,620,000 Saved

Analysis of Small Target Visibility Method

The Small Target Visibility (STV) Method is a way to determine visibility provided by lighting installations. The method was recently developed and was rapidly gaining momentum toward becoming a national standard.

Concerns by TxDOT lead to an in-depth evaluation of the new method through our research program. The evaluation found that the STV method had a number of flaws and did not warrant implementation in Texas, or nationally. Numerous assumptions were identified that could potentially introduce unrecognizable error in the final lighting design. Further, use of the STV method would increase design effort, significantly, by requiring the development of a complex computer simulation for each lighting installation.

These findings have caused the Illuminating Engineering Society of North America (IESNA) to re-examine the standards.



STV testing of roadway lighting

Benefits

- Preventing implementation of the STV method in Texas is estimated to have saved the department $150,000 in software equipment purchase and personnel training.
- Value of avoided inefficiencies in future lighting design efforts are estimated at $1,600,000 per year.
- Resources will not be expended to switch TxDOT back to our current methods once problems were discovered at some point in the future.

Impact Over First Ten Years:

$10,750,000 Saved

Alternate Polish Value and Soundness Specification Requirements (New Wet Weather Accident Reduction Program)

TxDOT began a Wet Weather Accident Reduction Program (WWARP) in 1974. The purpose of the program is to assure that positive practices are in place to reduce the rates of accident occurrence when pavements are wet and drivers experience reduced vision. A number of improvements to this important program have been made over the years.

A major program revision was recently made based in part on research which developed improved test methods for data collection and clarified the degree of correlation between aggregate properties and pavement skid performance. The new program is a three-phase system encompassing (1) wet weather accident analysis, (2) aggregate selection, and (3) skid testing and data analysis.

Wet weather reduces visibility and increases stopping distances

Benefits

- The new Wet Weather Accident Reduction Program (WWARP) is estimated to be reducing wet weather accidents by more than eight hundred each year in Texas.
- The WWARP allows roadway rehabilitation planners to make better-informed decisions.
- The new program facilitates TxDOT's responsiveness to wet weather accident locations.
- Because premium materials are used where they are most effective, Texas' natural resources are better utilized.
- In some cases, costs to rehabilitate pavements are reduced because local aggregate sources are acceptable.

Impact Over First Ten Years:

60 Lives Saved 8,060 Accidents Prevented

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